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DESIGN AND IMPLEMENTATION OF A PREPROCESSING SYSTEM FOR A SODIUM LIDAR

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ABSTRACT

A preprocessing system was designed and constructed for use with the University of Illinois sodium lidar system. The preprocessing system was developed to increase the altitude resolution and range of the lidar system and also to decrease the processing burden of the main lidar computer. This work describes the preprocessing system hardware and the software required to implement the system. Also presented are some preliminary results of an airborne sodium lidar experiment conducted with the preprocessing system installed in the sodium lidar.

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1. INTRODUCTION

1.1 University of Illinois Sodium Lidar Observations

Late in the 1930's a layer of sodium vapor was discovered in the earth's mesosphere. Observations of the layer since that time have determined that the layer is generally confined to an altitude range of 80 to 100 km with a peak density near 90 km. The upper and lower boundaries of the layer are sharply defined and seasonal and daily variations in the layer have been observed. The layer continues to be studied in order to gain a better understanding of the motions in the layer and the neutral and ion chemistry of the region.

Laser radar (lidar) has been used in the remote sensing of atmospheric constituents since the early 1960's. Initial nighttime lidar observations of the mesospheric sodium layer were conducted late in the 1960's in England [Bowman et al., 1969]. Since then, similar measurements by several sodium lidar groups in various locations have been reported. Initial lidar observations of the layer at the University of Illinois were made in 1977.

During the early experiments at the University of Illinois, emphasis was placed on observing relative structural changes in the layer [Richter and Sechrist, 1978]. In conjunction with this effort, a theory of sodium layer ion chemistry was developed [Richter and Sechrist, 1979]. To aid in the analysis of the data, signal processing techniques were developed and implemented [Rowlett and Gardner, 1979]. As the performance of the lidar system improved, theoretical and experimental studies of the response of the layer to gravity wave perturbations were conducted [Shelton and Gardner, 1981]. Recent interest has been directed toward studies of the horizontal structure of the layer and the implementation of a daytime sodium lidar system.

1.2 General and Sodium Lidar Concepts

Lidar is a remote sensing technique utilizing electromagnetic waves at optical frequencies. The detecting and locating of objects are accomplished by transmitting a laser pulse and analyzing the nature of the returned signal. Lidar systems require targets that exhibit scattering characteristics when subjected to a laser pulse such that a signal returning from the target is detectable above noise.

A basic lidar system consists of a pulsed laser, a receiving telescope, a photodetector such as a photomultiplier tube, and data collection electronics. The laser provides the transmitted pulse. Returning photons backscattered by the target are collected by the telescope. The photodetector converts the collected photons to electrical pulses which are analyzed and recorded by the data collection electronics.

The distance or range to the target is determined by measuring the elapsed time t_r between the transmitted and received pulses. The range R is given by

$$R = 1/2\ ct_r$$

where c = 3 x 10 m/s, the speed of light. The 1/2 accounts for the two-way propagation of the pulse. Further qualities of the target may be ascertained by observing the intensity and/or the pulse shape of the returning signal.

Sodium lidar utilizes the resonant scattering mechanism of neutral sodium atoms in the mesosphere. A pulse of light at a wavelength corresponding to a sodium transition line and incident on a mesospheric sodium atom causes a fluorescence which results in an enhancement of the returning signal. A tunable dye laser operating at 589.0 nm, the D_2 transition line

of sodium, is commonly used to provide the transmit pulse.

Sodium lidar receiving systems generally operate in a photon-counting mode and use a range gate collection technique. As the transmit pulse propagates through the mesosphere, backscattered photons are counted over short time intervals Δt. The set of counts from the sequential intervals is a record of the photocounts versus range. The "range gate width" ΔR is the range resolution of this type of system and is given by

$$\Delta R = 1/2c\Delta t.$$

The interval time Δt is often referred to as the "range gate time." "Range bin" is a term applied loosely to the storage location of the counts for a particular interval. The range R_i corresponding to the ith range bin is given by

$$R_i = 1/2c(t \;\; + \Delta t/2)$$

where t is the time elapsed between the transmitting of the laser pulse and the beginning of the collection of the counts in the ith range bin. An estimate of the density of a target at a particular range (for example, sodium density at 90 km) is obtained by examining the number of counts in the corresponding range bin.

Unfortunately, in most sodium lidar systems the signal-to-noise ratio for a single laser pulse is quite poor. A common method of increasing the signal-to-noise ratio is to integrate over many laser pulses. This simply involves collecting counts for single laser pulses as described above and then adding the range bin counts to corresponding range bin counts of previous laser pulses. The completed integration process results in a set of range bin counts which are collectively termed a "profile." The term "profile integration sum," in this report, refers to the range bin counts of an incomplete profile. The integration technique does increase the signal-

to-noise ratio but the time resolution of the system is decreased.

1.3 Objectives of This Investigation

The main objectives of this investigation were to design and implement a preprocessing system for use in the receiving section of the University of Illinois sodium lidar system. The system was designed and developed to increase the altitude resolution and range of the lidar system and also to decrease the processing burden of the main lidar computer by performing the integration of the data collected from successive laser shots.

A secondary objective is to present some preliminary results of an airborne sodium lidar experiment conducted by the University of Illinois Aeronomy Laboratory (Lidar Group) in conjunction with the National Aeronautics and Space Administration (NASA). The initial testing of the preprocessing system with the complete lidar system was conducted during this experiment, and the experimental results establish a high confidence level of operation for the preprocessing system.

2. UNIVERSITY OF ILLINOIS LIDAR SYSTEM

2.1 Introduction

Observations of the mesospheric sodium layer with lidar techniques began in 1977 at the University of Illinois [Richter and Sechrist, 1978]. The lidar system at this time consisted of a flashlamp-pumped dye laser developed at the University, a 0.38 m diameter Fresnel lens receiving telescope, a liquid nitrogen cooled photomultiplier tube (PMT), and a signal pulse discriminator and counter developed in a Physics Department research project. The system was located at the Aeronomy Laboratory Field Station near Urbana, Illinois. A Digital Equipment Corporation (DEC) PDP-15 computer at the Field Station directed the collection and storage of the data.

The next few years produced several changes in the Urbana lidar system. A counter interface was built to replace the Physics Department's pulse counter [Kinter, 1977]. The interface was designed to operate with an HP 2114A microcomputer which allowed the system to be independent of the Field Station PDP-15. In 1979, a 1.22 m diameter Fresnel lens telescope superseded the 0.38 m telescope [Rowlett and Gardner, 1979]. Also in 1979, a Digital Group Z-80 microcomputer replaced the HP 2114A [Teitelbaum and Sechrist, 1979]. Early in 1981, a flashlamp-pumped dye laser, built by the Candela Corporation, was purchased for the lidar system. This laser had better reliability and provided a higher pulse repetition rate than the previous laser. Two other items were also acquired early in 1981: an electrically cooled PMT housing which replaced the liquid nitrogen cooling system; and a pulse discriminator built by Princeton Applied Research, which replaced the Physics discriminator. Later in 1981, the lidar computer system

was again upgraded with a DEC LSI-11/2 microcomputer replacing the Z-80 [Vogel, 1982].

As the reliability and performance of the system increased, sodium lidar observations became feasible at sites other than Urbana. This allowed more diverse sodium lidar observations to be made as the lidar system was integrated with specialized pieces of equipment and facilities at other sites. In June 1981, October 1981, and May 1982 sodium lidar campaigns were conducted at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) near Greenbelt, MD. A steerable 48-inch astronomical telescope at GSFC allowed scanning-type (off-zenith) observations of the sodium layer to be made. In March 1983, an airborne sodium lidar experiment was conducted at the NASA Wallops Flight Center, Wallops Island, VA. Chapter 6 contains some preliminary results of this experiment.

The most recent addition to the lidar system is the preprocessing system described in the following chapters of this report. The preprocessing system replaces the old counter interface while also reducing the data processing burden of the LSI-11 main computer. The following sections of this chapter describe the lidar system hardware at the present time. A block diagram of the lidar system with the preprocessing system installed is shown in Figure 3.2 of Chapter 3.

2.2 Transmitting System

The principal component of the transmitting system is a Candela LFDL-1 flashlamp-pumped tunable dye laser utilizing Rhodamine 6G Perchlorate in a methyl alcohol and water solution. The laser consists of three subsystems: (1) a laser head which contains the optical cavity, dye cell, and flashlamp; (2) a refrigeration/circulation (chiller) unit used for both cooling and dye flow systems; and (3) a control unit/high voltage power supply. The laser

parameters are given in Table 2.1.

Laser tuning is achieved through a grating and an etalon in the laser cavity. Coarse tuning adjustments are made manually with the grating while fine adjustments are made with the etalon which is positioned by a Burleigh motor-micrometer. The wavelength of the laser beam is monitored by diverting a small fraction of the beam to a monochromator and to a hollow-cathode sodium discharge tube. The monochromator, in combination with a Reticon diode array line scanner (part numbers: RC 301, RL 256G), is used to display the intensity of the laser beam portion as a function of wavelength on an oscilloscope. The output of a sodium lamp is also displayed as a reference. Coarse tuning adjustments are monitored with this arrangement. Fine tuning adjustments are monitored by observing the laser-induced changes in the voltage between the electrodes of the gas discharge plasma in the hollow-cathode sodium tube (opto-galvanic effect). The electrode voltage is displayed on an oscilloscope.

Completing the transmitting system are the final laser beam output optics which generally include a beam expander to reduce beam divergence, and dielectric-coated mirrors to steer the laser beam.

2.3 Receiving System

The major components of the receiving system are the telescope, the photomultiplier tube (PMT) and its associated electronics, and the preprocessing and main computer systems. A 1.22 meter diameter f/1.56 acrylic Fresnel lens is the collecting element for the telescope utilized at the Urbana site. A detailed discussion of the telescope is provided by Rowlett and Gardner [1979]. A 48-inch Cassegrain astronomical telescope with Coude focus was employed for observations conducted at NASA Goddard Space Flight Center. The telescope is part of a versatile facility that also includes a

TABLE 2.1 CANDELA LFDL-1 LASER PARAMETERS.

Wavelength	589.0 nm
Pulsewidth (FWHM)	2 μsec
Linewidth	1 pm
Energy per pulse	50 mj
Pulse repetition rate	10 Hz
Beam divergence	1 mrad
Flashlamp lifetime	3 x 10^6 shots

computer-controlled pointing system capable of tracking stars and satellites. The airborne lidar system at NASA Wallops Flight Center utilized a 16-inch diameter primary, Newtonian configured telescope.

The telescope optics required for the 1.22 m Urbana telescope are shown in Figure 2.1. The collected photons are focussed by the Fresnel lens onto the plane of a field-stop iris. Beyond the iris, the beam is collimated by a Nikon 35 mm f/1.4 lens prior to its passage through an interference filter. The interference filter is used to reduce the number of photons due to background sky illumination. Two temperature controlled filters with bandwidths of 5 and 0.5 nm are currently used with the system. The filter selected for a particular experiment depends on the experimental objectives, received signal intensity at the time of the experiment, etc. A lens in the PMT housing focusses the photons passed by the filter onto the cathode of an RCA C31034A PMT. To reduce dark counts, the PMT is thermoelectrically cooled by a Products for Research Model TE-206TS-RF cooled housing.

Due to the relatively long focal lengths of the 48-inch Goddard telescope (1300 in, f/27) and the 16-inch Wallops telescope (approximately 400 in, f/25), the receiving optics arrangement following these telescopes is simplified from that shown in Figure 2.1. The long focal lengths provide a nearly collimated beam of collected light at the focus of the telescope. Therefore, the field-stop iris and the Nikon collimating lens are not required in front of the interference filter and the PMT focusing lens is positioned at the focal point of the telescope.

The output of the PMT is applied to a Princeton Applied Research Model 1121 Amplifier-Discriminator. The discriminator compares the pulses generated by the PMT to a preset threshold level. NIM standard (18 mA (- 1 V), 12 nsec) and emitter-coupled logic (ECL) level pulses are produced

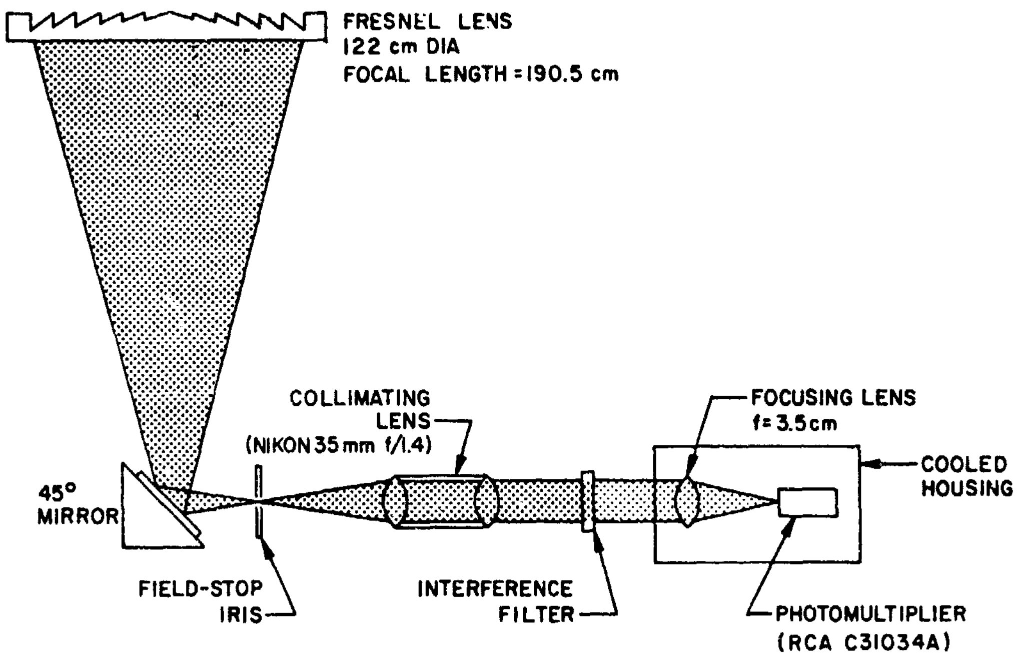

Figure 2.1 Schematic diagram of 1.22 m telescope optics [Rowlett and Gardner, 1979].

by the discriminator after receiving PMT pulses that exceed the threshold. The discriminator pulses (currently from the NIM standard output) are counted by the preprocessing system.

At very high counting rates (above 20 MHz) the PMT is subject to overloading conditions which cause significant errors in the recorded number of detected photons. Strong Rayleigh scattering of the laser beam below 30 km altitude consistently provides very high counting rates that disturb counts collected from altitudes below 30 km as well as those collected from altitudes above 30 km as the PMT is recovering. A PMT blanking controller and a timing controller were constructed to alleviate PMT overloading due to Rayleigh scattering [Shelton and Gardner, 1981].

The blanking controller achieves the blanking or gating of the PMT by reducing the voltage of the first dynode of the PMT with respect to the PMT cathode potential, effectively decreasing the overall gain of the PMT. Measurements on this system indicate the gain is reduced by approximately 3 orders of magnitude. The PMT recovery time after blanking has been observed to be on the order of 6 to 10 μsec. Therefore, the blanking controller can be engaged to blank the PMT as scattered signal below 30 km altitude is collected, and disengaged for data collection above 30 km altitude.

The timing controller synchronizes the firing of the laser and the PMT gating. The triggering of the timing controller is initiated by a pulse received from the preprocessing system. After triggering, the timing controller engages the blanking controller and delays 5 μsec before sending a trigger pulse to the laser. The delay ensures the blanking of the PMT is complete as the laser fires. Approximately 200 μsec after the laser triggering (corresponding to an altitude of 30 km), the blanking controller is disengaged and data collection continues. A variable resistor in the timing

controller sets the blanking duration.

The preprocessing and LSI-11 main computer systems are discussed in the following chapters. In general, the preprocessing system initiates the laser firing, counts the discriminated pulses from the amplifier-discriminator, and integrates the counts from consecutive laser shots. The main computer directs the overall experiment and permanently stores the collected data on a floppy disk.

3. THE PREPROCESSING SYSTEM

3.1 Introduction

The sodium lidar preprocessing system is designed to direct the collection of data for one concentration vs. altitude profile of the mesospheric sodium layer. The system controls laser firing, counts the returning discriminated photon pulses, sections the counts into appropriate range bins, and integrates similar range bins over consecutive laser shots to form a profile. Completed profiles are sent to a main computer for further processing and storage. As mentioned previously, the system was devised to decrease the data processing burden of the main computer.

The system consists of two major pieces of hardware: an Apple II Plus microcomputer and the Sodium Lidar Preprocessing (SLIPP) interface unit. Other hardware items include a Direct Memory Access (DMA) circuit for the Apple-SLIPP unit communications and a RS-232 standard serial communications link between the Apple and the main computer. Software routines drive the Apple and the main computer.

The Apple computer masterminds the profile collection. All communications with both the SLIPP unit and the main computer, laser firing, and integrations are handled through the Apple's software. The range bin counts and the profile integration sum are stored in the Apple's Random Access Memory (RAM). The Apple also displays messages on its video screen to notify the lidar operator of the present status of the system.

The SLIPP unit interfaces the Apple to the transmitting and receiving sections of the lidar system. Line driver circuitry in the SLIPP unit allows the laser to be triggered by the Apple. After a laser shot the received photon pulses are counted in the SLIPP unit. The SLIPP unit has no

memory of its own so each range bin collected is immediately transferred to the Apple RAM through the DMA circuitry.

Although not strictly considered part of the preprocessing system, the lidar main computer and its software are closely associated with the preprocessing system. The main computer for the University of Illinois lidar system is a DEC LSI 11/2 computer. The LSI-11 directs the overall experiment. It is programmed with the information on time to collect a data profile and the number to collect. Through the LSI-11 terminal the lidar operator is able to access and change these experiment parameters. An RS-232 standard serial communications link allows the LSI-11 to send commands to the Apple and the Apple to send data profiles back to the LSI-11. The LSI-11 also gives the operator a summary of each of the completed profiles and stores the profiles on a floppy disk.

3.2 Data Acquisition Timing

The desired pulse repetition rate of the laser and the desired rate of collecting data profiles were two parameters of particular interest during the designing of the preprocessing system. The system had to be able to integrate data from consecutive laser shots with enough speed to let the laser operate at its maximum pulse rate (10 Hz), and the data transfer from the preprocessing system to the main computer had to be reasonably fast so as not to cause any long delays between data profiles. Figure 3.1 is a timing diagram of the data collection process timing for the completed preprocessing system.

Part (a) of Figure 3.1 shows the collection process for a single laser pulse. The laser is initially triggered by the preprocessing system. Two thousand range bins of data are then immediately collected. This requires about 2000 μsecs as the range gate time is 1 μsec for each bin. Another

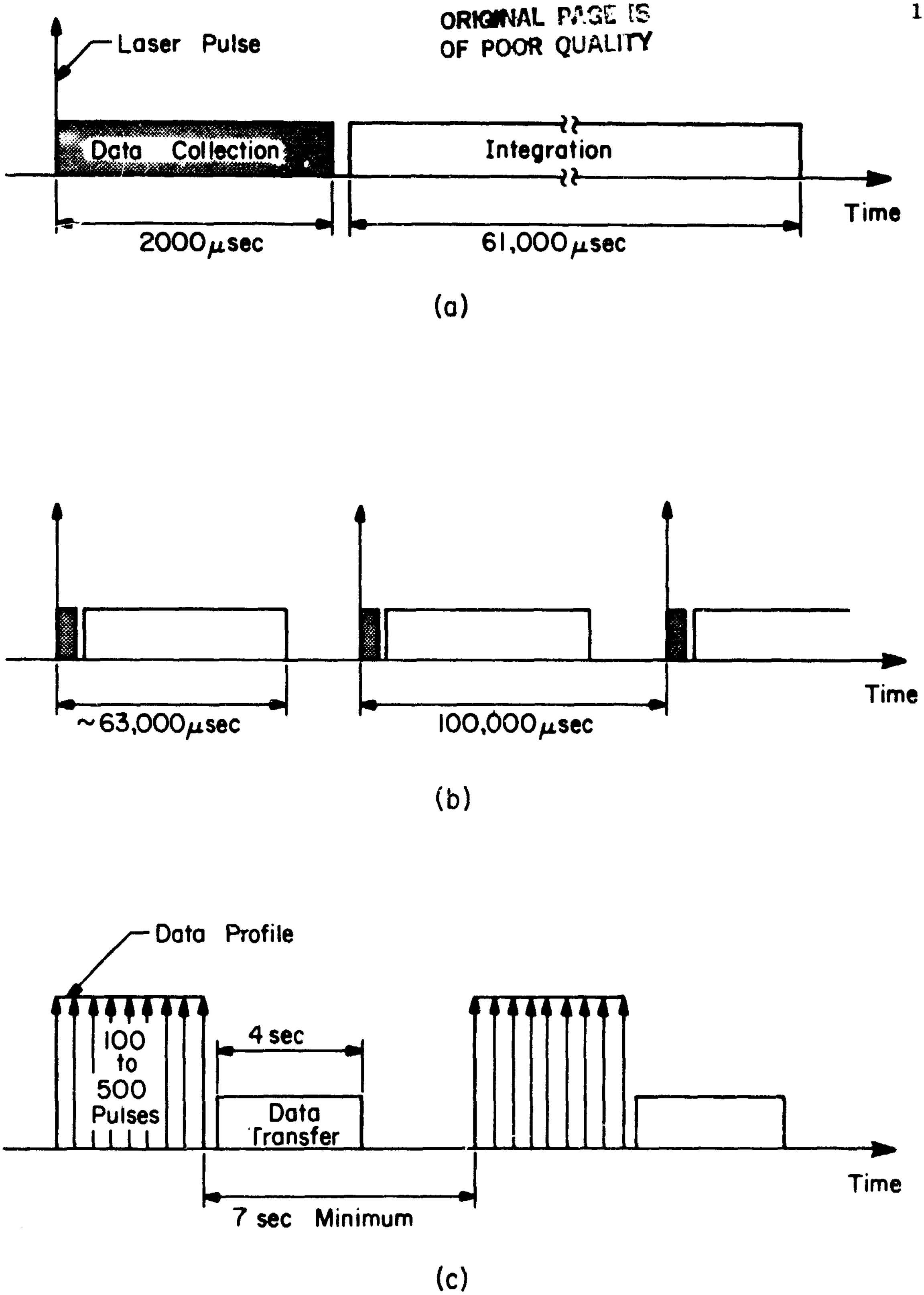

Figure 3.1 Data acquisition timing for: (a) a single laser pulse, (b) repeating laser pulses, and (c) full profiles.

61,000 μsecs are required by the Apple to integrate the data from the current laser shot into the profile integration sum. Therefore, the data preprocessing requires about 63,000 μsec total per laser pulse.

Repeating laser pulses at 10 Hz are shown in part (b) of Figure 3.1. The data collection and integration times are denoted after each laser pulse. It is evident that the preprocessing system is able to operate with laser pulse rates exceeding 10 Hz.

Part (c) of Figure 3.1 shows the collection of completed profiles. A data profile is stored in Apple RAM as 2000 16-bit words. Therefore, roughly 4 seconds are required for the Apple to send the completed profile over the serial link to the LSI-II at 9600 baud. The LSI-11 uses another 3 seconds to store the profile on a floppy disk and give the operator a summary of the profile. The total delay of 7 seconds between the end of one profile and the beginning of the next is tolerable. More details on system timing are included in Section 3.4 on system parameters.

3.3 System Operation Description

This section describes in general terms the interactions of the preprocessing system with the rest of the lidar system during the collection of a data profile. Figure 3.2 is a block diagram of the lidar system with the preprocessing system installed. Some of the block items in the figure are explained in more detail in Chapter 2 on the lidar system hardware. The figure is a useful reference for the following discussion on the system operation.

A lidar data run begins with the operator inputting or changing experiment parameters on the LSI-11 terminal. These parameters include the number of profiles per set, the profile range bins to be saved, laser rep rate, etc. (see Section 5.2.2). Once the operator has initiated a data run,

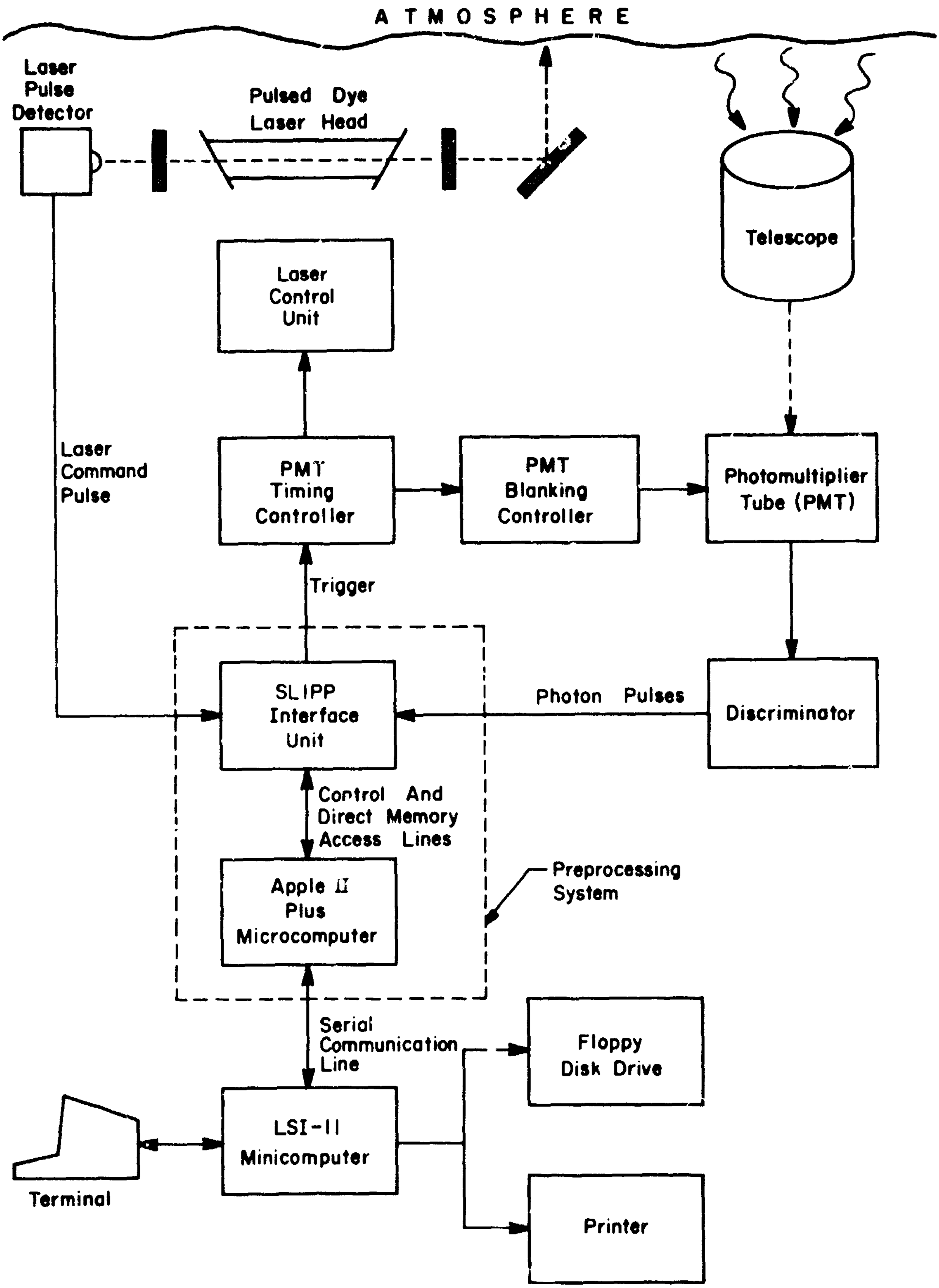

Figure 3.2 Lidar system with preprocessing system installed.

the LSI-II sends two communication frames to the Apple over the serial link. The first frame contains information on the desired laser pulse rep rate and the desired number of laser shots per profile. The second frame signals the Apple to begin collecting a profile.

The first action of the Apple upon the receipt of the "data run" frame is to initialize the DMA circuitry for data transfer from the SLIPP unit to the Apple RAM. Next, the Apple clears the block of RAM that holds the profile integration sum. Finally, the Apple sends the laser trigger pulse to the SLIPP unit. The laser pulse not only passes through the SLIPP unit to trigger the laser and the PMT timing circuitry but also enables the SLIPP unit for counting.

Once enabled, the SLIPP unit waits for the Laser Command Pulse (LCP). This is a positive logical pulse that is generated by a laser pulse detector when the laser fires. The LCP notifies the SLIPP unit that the laser has fired and the unit begins counting photon pulses in 1 μsec intervals. At this point the DMA circuitry takes control of the Apple buses and each interval, or range bin, collected is immediately stored in the Apple RAM through DMA. The SLIPP unit actually uses two toggling counters in order that during any 1 μsec interval, one counter is counting photon pulses while the contents of the other counter are being placed in memory. When all of the range bins are collected, normally 2000, the DMA circuitry disables the SLIPP unit and the Apple regains control of its address and data buses.

Next, the Apple checks a status bit in the DMA circuit to be sure the DMA occurred. If the bit is not set a problem occurred, such as the laser never fired, and the Apple jumps to an error routine. With the bit set, the Apple adds the new range bin counts into the profile integration sum. The collection process is now complete for one laser shot. The Apple checks to

see if the profile requires more laser shots. If so, the Apple sends the next laser trigger pulse, enables the SLIPP unit, and the collection begins again. If the profile is complete it is sent over the serial link to the LSI-11.

After receiving the profile the LSI-11 does some simple calculations and gives the operator a summary of the profile (see Section 5.2.2 for more details). The summary is given both on the terminal and a hard copy printer. The data are stored on a floppy disk and the collection of one profile is complete. If more profiles are to be collected, the LSI-11 sends the "data run" frame to the Apple again. If the set of profiles is finished the LSI-11 alerts the operator and waits for the next command.

3.4 System Parameters

This section contains descriptions and values of the important parameters of the preprocessing system. Definitions of some of the terms used in this section can be found in Section 1.2. A list of the parameter values is given in Table 3.1.

Range Gate:

The range gate time is fixed by the logic in the SLIPP interface unit at 1 μsec. This corresponds to a range gate width of 150 meters for each range bin. This is the maximum resolution of the system.

Range Bins:

The preprocessing system currently collects 2000 range bins of data for each laser shot. With the 1 μsec range gate time mentioned above, the total system range is 300 km. The number of range bins used for data collection may be changed with a few Apple software alterations.

Photon Pulse Count Bandwidth:

The counters and associated logic in the SLIPP interface unit are

TABLE 3.1 PREPROCESSING SYSTEM PARAMETERS.

Range gate time	1 μsec
Number of range bins	2000
Photon pulse input (NIM)	-18 mA(≃ -1 V), 12 nsec
Photon pulse count bandwidth	50 + MHz
Inter-profile period	7 sec

capable of detecting NIM standard (-18 mA (-1 V), 12 nsec) signal pulses with rates exceeding 50 MHz. However, the discriminator used by the University of Illinois sodium lidar (P.A.R.C. Model 1121) which provides the pulses for the counters is rated at only 37 MHz for random pulses. It is also apparent that the PMT in the sodium lidar system (RCA C31034A) generally overloads at count rates approaching 20 MHz. The SLIPP unit was also designed for possible future expansion to a balanced, emitter-coupled logic (ECL) compatible, 5 nsec pulse count input. This would reduce noise created in the cable between the discriminator and the SLIPP unit. The balanced ECL and standard NIM outputs are both provided by the P.A.R.C. 1121 discriminator.

Data Acquisition Rate:

The time necessary to obtain one sodium data profile is, of course, dependent on the number of laser shots required and the laser repetition rate. A little more than 4 seconds are necessary for a profile to be transferred from the Apple to the LSI-11. Three seconds are required by the LSI-11 to display a summary of the profile on the terminal and printer, and store the profile on a floppy disk. Therefore, with a laser operating at 10 Hz, a profile requiring 100 shots can be collected in about 17 seconds.

Data Storage:

Apple Memory - The Apple Random Access Memory is used to temporarily store the incoming range bin counts and the profile integration sum. The range bin counts are recorded in 2000 8-bit bytes in an area of memory designated as "buffer memory." Two thousand integration sum bins are each 16 bits in length and stored in an area designated as "mainframe memory." For programming ease 2048 (2K) bytes are allocated as buffer memory and 4096 (4K) bytes are allocated as mainframe memory. The high order bytes and the

low order bytes of the 16-bit words in the mainframe memory are divided into two sections. This is a result of the addition routine used by the Apple to form the profile integration sum.

LSI-Memory - A profile is sent from the Apple to the LSI-11 with the low order bytes of the 16-bit words first and the high order bytes second. The bytes are assembled upon receipt by the LSI-11 into 16-bit words and stored in the array LDATA.

LSI-11 Floppy Disk - The LSI-11 computer permanently stores sets of sodium data profiles on a floppy disk with a DEC floppy disk drive (both RX01 and RX02 type drives have been used). The profile sets are stored as unformatted direct access files. The name assigned to each file is SETxxx.DAT, where xxx is the number of the set. For example, SET001.DAT is the file name for the first set collected in a data run.

4. CIRCUITS DESCRIPTION

4.1 Apple Direct Memory Access Circuit

4.1.1 Introduction. Direct Memory Access is a fast and efficient method of transferring data to or from a computer's memory. This method involves a specialized device communicating directly with the computer's memory. The data transfer can therefore be performed with minimum interaction from the microprocessor (MPU). The sodium lidar preprocessor design requires the Apple's Random Access Memory to store incoming photon counts from the SLIPP interface unit. The counts are recorded in bytes every microsecond which corresponds to a data transfer rate of 1 Mbyte/sec. This rate is much too fast for the Apple to handle in a software polling loop or an interrupt routine. Therefore, DMA is a necessity. The DMA controller selected for this project was the Motorola MC6844 Direct Memory Access Controller (DMAC) chip. The chip was designed for use with the Motorola MC6800 series microprocessors. However, strong similarities between the MOS 6502 microprocessor in the Apple and Motorola's MC6800 allow the MC6844 DMAC to work ell with the Apple's circuitry.

4.1.2 Apple timing. All clock signals, memory strobe signals, and video signals in the Apple II Plus are derived from a single 14.138 MHz oscillator on the main Apple circuit board. The various signals are obtained by using a number of counters, shift registers and multiplexers. Figure 4.1 is a typical timing diagram for some of the Apple signals. 7M is an intermediate timing signal, $\Phi 0$ and $\Phi 1$ are system clocks, and Q3 is an asymmetrical general-purpose timing signal. The $\Phi 0$ Apple clock is comparable to the $\Phi 2$ clock of other microprocessor systems.

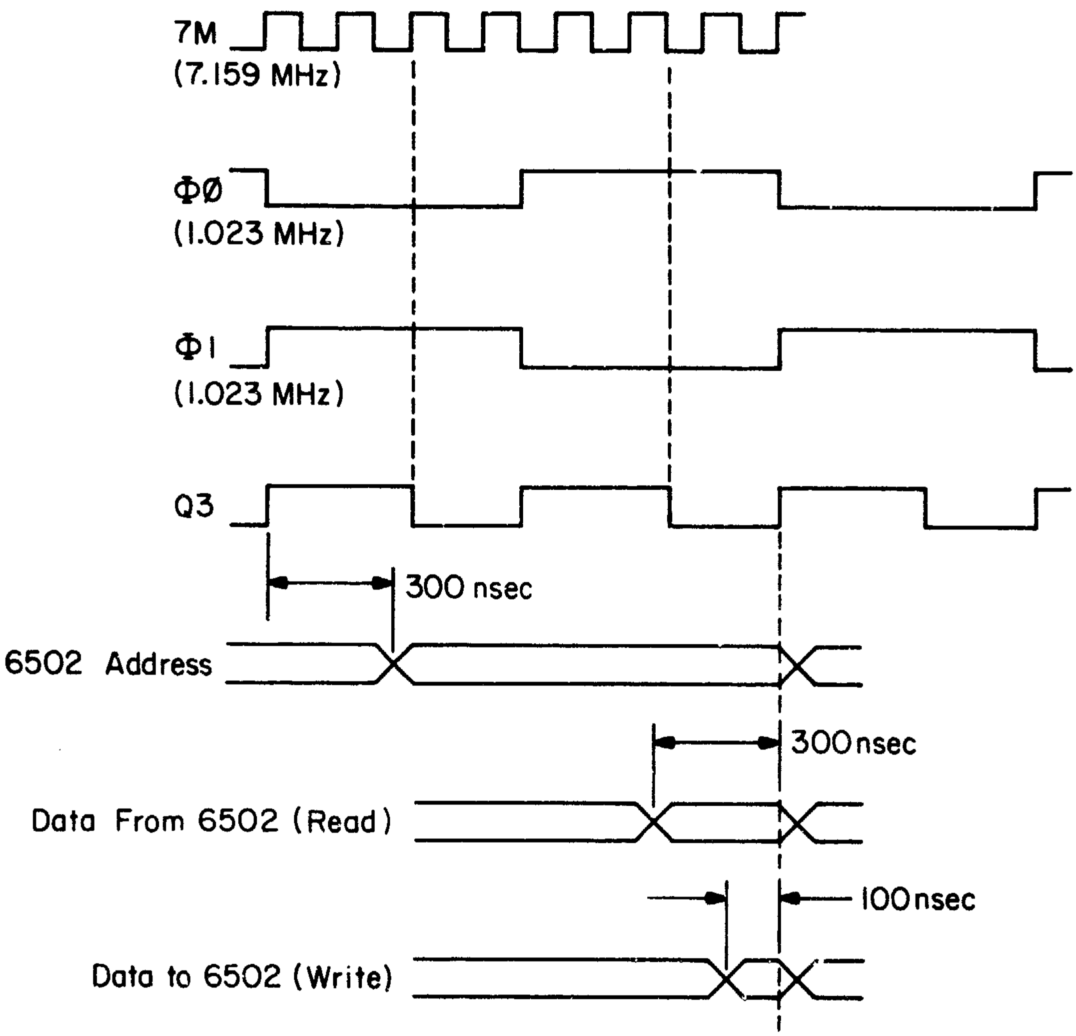

Figure 4.1 Apple timing signals.

During normal operation the Apple's RAM is used by both the 6502 and the Apple's video generating circuitry. The 6502 accesses the RAM only during the high (+5 volts) half of the $\Phi 0$ clock while the video generating circuitry updates the video screen from the RAM during the low (ground) half of the $\Phi 0$ clock. The action of the video circuitry also refreshes all of the Apple's RAM. Because of this feature, the easiest implementation of the DMA controller is to have it essentially replace the 6502 during DMA data transfer periods. This implementation allows the video circuitry to continue to function normally during a DMA period. Another result of this type of DMA architecture is that the data transfer rate is dictated by the microprocessor system clock rate, $\Phi 0$ for the Apple, which would allow a maximum DMA transfer rate of 1.023 Mbyte/sec. The MC6844 DMAC was chosen because it is designed for the type of implementation discussed above and it is capable of operating at the Apple system clock rate.

One peculiarity of the Apple timing system is that every 65th cycle of the $\Phi 0$ and $\Phi 1$ clocks is lengthened by about 140 nanoseconds. This corresponds to a frequency of 0.895 MHz for the long cycle. The lengthening is an artifact of the logic used to obtain the clock signals from the 14.318 MHz oscillator. Because of this anomaly, the SLIPP interface unit was designed with its own oscillator and clock logic rather than using the Apple's. In order to place photon pulse counts in correct range bins the SLIPP unit must be able to determine accurately the time elapsed since the laser firing. This would not be possible with the Apple's inconsistent clock. This design results in the Apple and the SLIPP unit operating asynchronously. To account for the timing differences, an asynchronous First-In/First-Out buffer (FIFO) is used to interface the SLIPP unit and the Apple DMA circuit. For more details on the interfacing see Section 4.2.4.

4.1.3 <u>Apple peripheral input/output</u>. Along the rear edge of the Apple's main board are eight peripheral connectors. The connectors or "slots" are labeled 0 through 7 beginning from the left-hand side of the board. Slots 1 through 7 are used for most peripheral applications while slot 0 was designed specifically for memory or interface expansion. The pinout for the slots is shown in Appendix I. The preprocessor DMA card was designed to be used in any of the slots 1 through 7.

Each slot has specific memory locations assigned to it. This memory-mapped structure allows the user (or user's program) to access cards in any of the slots. Each slot is given 16 locations for general input and output purposes. The locations for the particular slots are listed in Table 4.1. Whenever the MPU calls an address within the 16-byte allocation of a particular slot, the $\overline{\text{Device Select}}$ line (pin 41) on that peripheral connector will become active (drop to ground). By listening to the $\overline{\text{Device Select}}$ line, a peripheral card can determine when a byte in the general I/O space reserved for it is being addressed.

In addition to the 16 general I/O locations, each slot is assigned 256 locations (one page) of Read Only Memory (ROM) or Programmable ROM (PROM) space. These locations are listed in Table 4.2. Although allocated as peripheral card program space, these locations function in a similar manner as the general I/O locations. Whenever an address within the one page allocation of a particular slot is called, the $\overline{\text{I/O Select}}$ line (pin 1) on that peripheral connector will become active (drop to ground). A peripheral card can determine when its program space is being addressed by listening to the $\overline{\text{I/O Select}}$ line. The Apple accesses the preprocessor DMA card through both the general I/O and the program locations. The general I/O addresses are decoded on the DMA card to provide control signals for

TABLE 4.1 APPLE PERIPHERAL CARD GENERAL PURPOSE I/O LOCATIONS.

SLOT	LOCATIONS
0	\$C080-\$C08F
1	\$C090-\$C09F
2	\$C0A0-\$C0AF
3	\$C0B0-\$C0BF
4	\$C0C0-\$C0CF
5	\$C0D0-\$C0DF
6	\$C0E0-\$C0EF
7	\$C0F0-\$C0FF

TABLE 4.2 APPLE PERIPHERAL CARD PROM LOCATIONS.

SLOT	LOCATIONS
1	\$C100-\$C1FF
2	\$C200-\$C2FF
3	\$C300-\$C3FF
4	\$C400-\$C4FF
5	\$C500-\$C5FF
6	\$C600-\$C6FF
7	\$C700-\$C7FF

firing the laser, resetting the SLIPP unit, etc. The program locations are used to access the MC6844 DMAC programmable Control Registers.

A DMA transfer with the Apple is accomplished by pulling the $\overline{\text{DMA}}$ line (pin 22) on the connector LOW. This disables the 6502's address bus and interrupts the clock to the 6502, effectively halting the microprocessor. A peripheral controller, such as the MC6844 DMAC, is able to supply the Apple RAM addresses while the $\overline{\text{DMA}}$ pin is held LOW.

Other line present on the peripheral connector that are used by the DMA card include the clock signals $\Phi 1$ and Q3 (pins 38 and 37), the Read/Write line R/$\overline{\text{W}}$ (pin 18), and the Reset line $\overline{\text{RES}}$ (pin 31).

The Apple peripheral connectors also provide pins to construct a daisy chain priority system for cards that issue interrupt or DMA requests. These pins are labeled INT IN, INT OPUT, DMA IN, and DMA OUT (pins 28, 23, 27 and 24, respectively). The system was designed for the highest priority device to be installed in the left most slot of the Apple slots 1 through 7. It was apparent that in the preprocessing system the DMA card would not have any conflicts with other devices issuing DMA requests. Therefore, rather than constructing some arbitration logic testing for DMA request conflicts, the DMA IN and DMA OUT pins on the card were simple connected together to preserve the DMA daisy chain. The preserve the interrupt daisy chain, the INT IN and INT OUT pins on the card were connected together.

4.1.4 The MC6844 DMAC. The MC6844 Direct Memory Access Controller is a TTL compatible chip that directs the DMA data transfer from the SLIPP unit to the Apple. It controls the address bus and the Read/Write line in the Apple in place of the 6502 during a DMA transfer.

The MC6844 has three modes of operation and four DMA channels. The operation modes are as follows: 1) Three State Control (TSC) Steal - in

this mode the MPU 2 clock is stretched while one byte of data is transferred; 2) Halt Steal - the MPU is halted while one byte of data is transferred; 3) Halt Burst - the MPU is halted while an entire block of data is transferred. The mode of operation selected depends on the transfer rate required with the Halt Burst mode giving the highest rate. The preprocessor DMA card was designed to use one channel of the MC6844 in the Halt Burst mode.

The MC6844 pinout is shown in Figure 4.2. Before a DMA transfer begins, the DMAC must be programmed with the data transfer location and length, transfer mode, priority of servicing, data chaining, and interrupt control. The programming is accomplished through the first five address lines (A0-A5), the data bus, and the chip select pin ($\overline{CS}$) on the DMAC. Tables 4.3 and 4.4 show the programmable registers of the MC6844. These tables are provided as a quick programming reference. More DMAC programming details are provided in the Motorola specification sheets on the MC6844.

TxRQ0 through TxRQ3 (pins 29-31) are the transfer request lines. There is one request line for each of the four channels. A peripheral device requests a DMA transfer by driving the transfer request line on a particular channel HIGH. The preprocessor DMA card uses only channel #1 of the DMAC.

Transfer acknowledge outputs notify the device requesting a transfer that the request has been received by the MC6844. The transfer acknowledge signals are TxAKA and TxAKB. The Transfer Strobe line ($\overline{TxSTB}$) is a general acknowledge line which is also intended for use as the system Valid Memory Address (VMA) signal.

After a transfer request has been received by the DMAC, the DMAC must issue a request to the system's MPU. This is done with either of the two

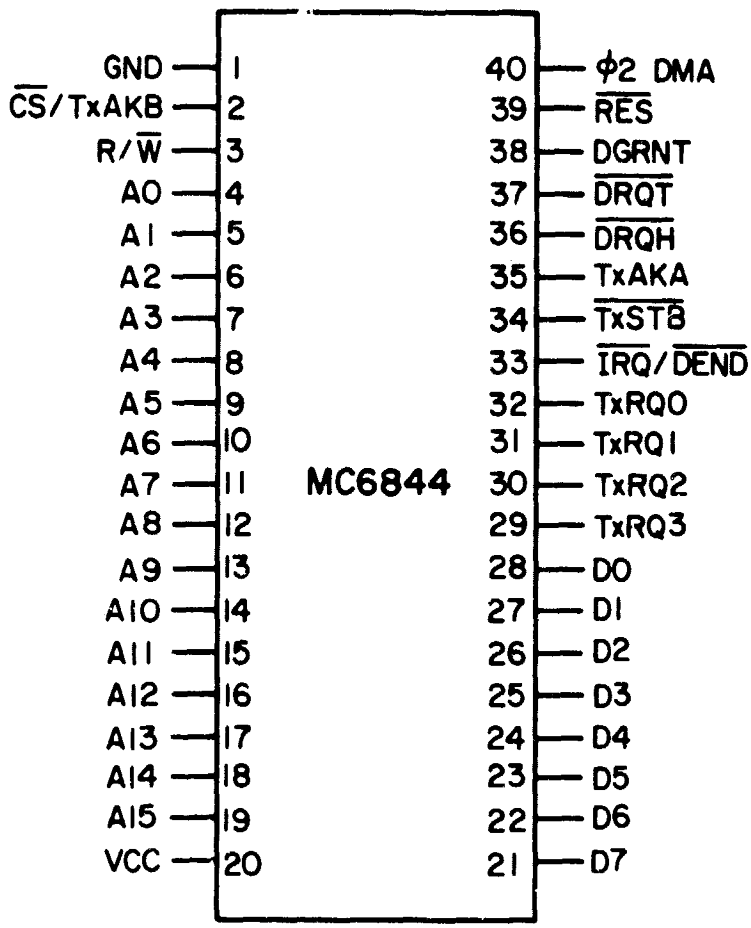

Figure 4.2 MC6844 DMAC pinout.

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TABLE 4.3 MC6844 ADDRESS AND BYTE COUNT REGISTERS.

REGISTER	CHANNEL	ADDRESS (HEX)
ADDRESS HIGH	0	0
ADDRESS LOW	0	1
BYTE COUNT HIGH	0	2
BYTE COUNT LOW	0	3
ADDRESS HIGH	1	4
ADDRESS LOW	1	5
BYTE COUNT HIGH	1	6
BYTE COUNT LOW	1	7
ADDRESS HIGH	2	8
ADDRESS LOW	2	9
BYTE COUNT HIGH	2	A
BYTE COUNT LOW	2	B
ADDRESS HIGH	3	C
ADDRESS LOW	3	D
BYTE COUNT HIGH	3	E
BYTE COUNT LOW	3	F

TABLE 4.4 MC6844 CONTROL REGISTERS.

REGISTER	ADDRESS (HEX)	REGISTER CONTENTS							
		BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
CHANNEL CONTROL	1x*	DMA END	BUSY/ READY	-	-	UP/ DOWN	TSC/ HALT	BURST/ STEAL	READ/ WRITE
PRIORITY CONTROL	14	ROTATE C'NTRL	-	-	-	R'QST ENB 3	R'QST ENB 2	R'QST ENB 1	R'QST ENB 0
INTERRUPT CONTROL	15	DEND IRQ FLAG	-	-	-	DEND IRQ ENB 3	DEND IRQ ENB 2	DEND IRQ ENB 1	DEND IRQ ENB 0
DATA CHAIN	16	-	-	-	-	2/4 CH'NL SELECT	DATA CHAIN SEL B	DATA CHAIN SEL A	DATA CHAIN ENB

*The x represents the binary equivalent of the channel desired.

outputs DMA Request TSC-Steal ($\overline{DRQT}$) or DMA Request Halt-Steal ($\overline{DRQH}$). The $\overline{DRQT}$ line is normally connected to the system clock driver and used to request a MPU clock stretch for the TSC-Steal transfer mode. The $\overline{DRQH}$ line is connected to the MPU Halt pin and requests a transfer in the halt steal or halt burst mode.

After issuing a request to the MPU, the DMAC waits for a bus available signal. This signal is generally output from the MPU or the MPU clock circuitry and is presented to the DMA Grant pin (DGRNT). The DMA transfer begins once this signal is received.

The Interrupt Request output and the DMA End signal are provided on the dual purpose line $\overline{IRQ}/\overline{DEND}$. The $\overline{IRQ}$ output is used to interrupt the MPU and signal the peripheral device that a DMA transfer has ended. If the Interrupt has been enabled, the $\overline{IRQ}/\overline{DEND}$ line will go LOW <u>after</u> the last byte of a transfer. The $\overline{IRQ}/\overline{DEND}$ line also goes LOW <u>during</u> the last byte of a transfer to signal the DMA End. This occurs whether the Interrupt is enabled or not.

Other pins on the MC6844 include Read/Write (R/$\overline{W}$), the clock input (Φ2 DMA), and Reset ($\overline{RES}$).

One option supported by the MC6844 and used by the preprocessing system is data chaining. Data chaining allows the repetitive reading or writing of a block of data without reloading the DMAC Address and Byte Count registers for each transfer. The chaining is performed by transferring the contents of the Address and Byte Count Registers in channel #3 to the channel selected by the programming of the Data Chain Control Register. The transfer automatically occurs after the Byte Count Register of the selected channel has decremented to zero.

It should be noted that during a DMA transfer the DMAC is only supplying addresses for the system's memory at the MPU clock rate. The peripheral device requesting the transfer must write (or read) the data on the data bus at the MPU clock rate.

4.1.5 DMA circuit description. The Apple DMA circuit for the preprocessing system was designed to transfer a block of data to (or from) the Apple RAM at a rate of 1.023 Mbytes/sec. The circuit was constructed on a 2-3/4" x 7" Apple II Peripheral Board and consists of the MC6844 DMAC chip supported by ten low-power Schottky (LS) TTL chips. Connecting the Apple and the DMA card to the peripheral device requesting a DMA transfer is a 34-pin shielded ribbon cable. A connector for the cable is mounted on the DMA board. The card was designed to operate in any of the Apple peripheral slots 1 through 7 on the back of the main Apple board (see Section 4.1.3). The Apple slot pinout and the ribbon calbe pinout are listed in Appendix I. The locations of the components on the DMA card are noted in Appendix II. Figure 4.3 is the wiring schematic for the DMA card. The timing for a typical DMA transfer is shown in Figure 4.4.

Both the Apple ROM I/O locations and general I/O locations are used to cmomunicate with the DMA card (see Section 4.1.3). The ROM I/O locations access the DMAC Control Registers while the general I/O locations are decoded and used as "Control Signals." Table 4.5 lists the DMA card I/O locations. The DMAC Control Registers are programmed through the first five address lines (A0-A4), the data bus, and the chip select pin (CS) on the DMAC (see Section 4.1.4). The CS pin must be pulled LOW while programming the DMAC registers. This is accomplished by the decoding of the Apple I/O Select line and the address lines A5 through A7 with a 74LS260 5-input NOR (chip U6 in Figure 4.3). The decoding allows 32 addresses to activate the

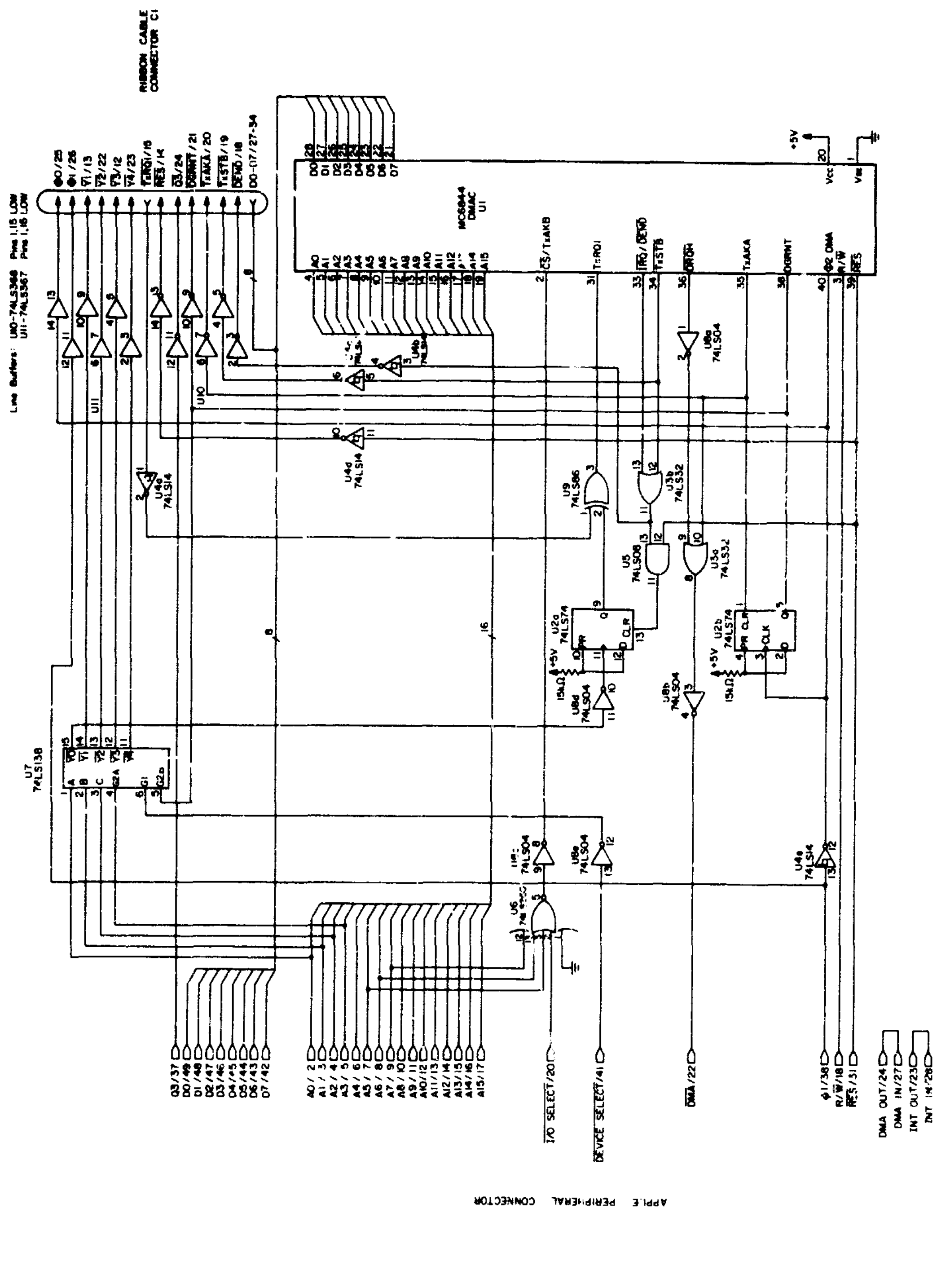


Figure 4.3 Apple DMA card circuitry.

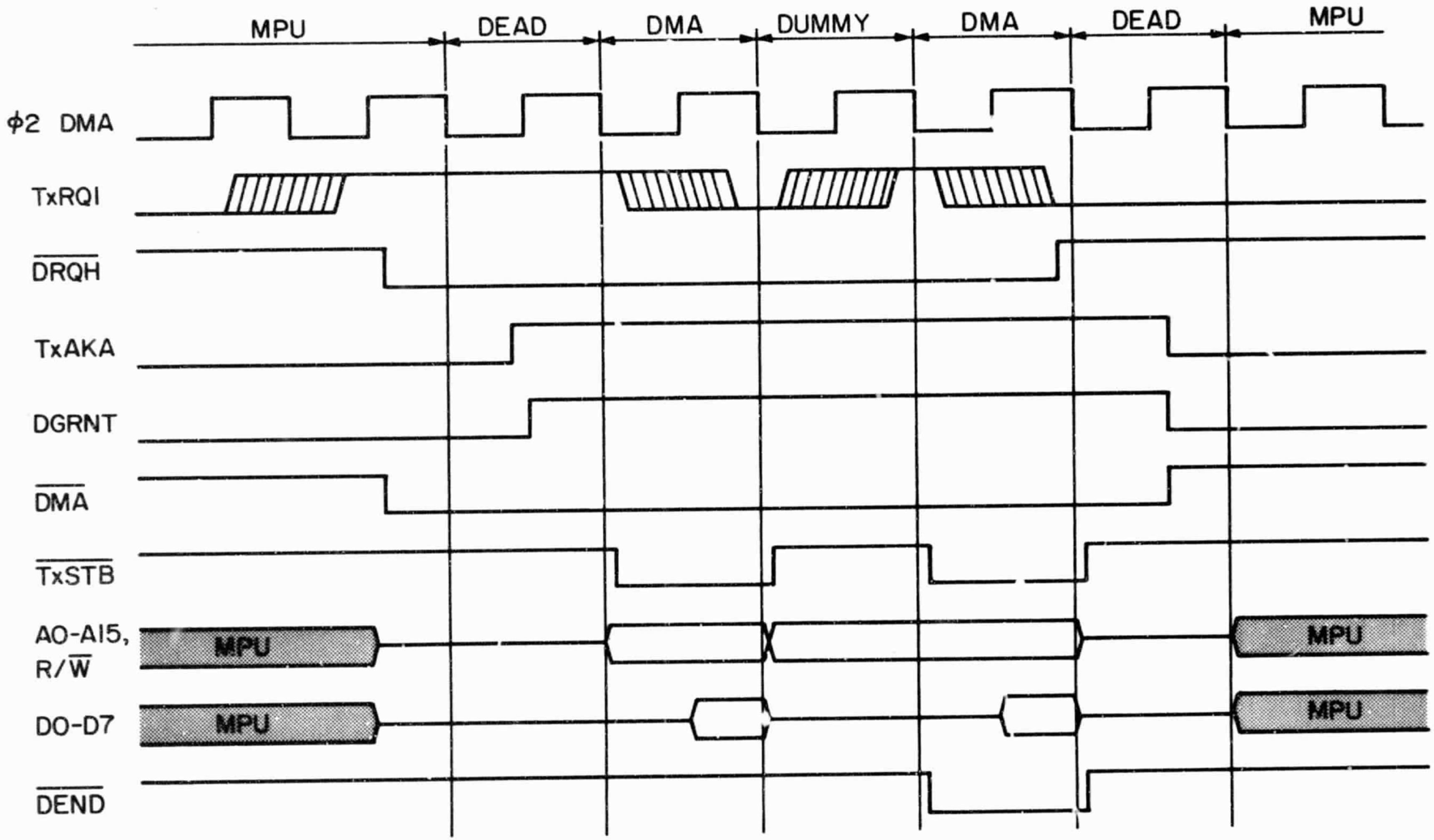


Figure 4.4 Apple DMA card transfer timing.

TABLE 4.5 APPLE DMA CARD I/O LOCATIONS.

LOCATION TITLE	ADDRESS[1]	DESCRIPTION[2]
	\$Cn00 - \$Cn0F[3]	ADDRESS AND BYTE COUNT REGISTERS
DMAC CONTROL	\$Cn10 - \$Cn13[3]	CHANNEL CONTROL REGISTERS
REGISTERS	\$Cn14	PRIORITY CONTROL REGISTER
($\overline{\text{I/O}}$ $\overline{\text{SELECT}}$)	\$Cn15	INTERRUPT CONTROL REGISTER
	\$Cn16	DATA CHAIN REGISTER
	\$C0x0	$\overline{\text{Y0}}$ - APPLE DMA TxRQ
CONTROL	\$C0x1	$\overline{\text{Y1}}$ - (LASER TRIGGER)
LINES	\$C0x2	$\overline{\text{Y2}}$ - (AUX OUTPUT)
($\overline{\text{DEVICE}}$ $\overline{\text{SELECT}}$)	\$C0x3	$\overline{\text{Y3}}$
	\$C0x4	$\overline{\text{Y4}}$ - (SLIPP UNIT RESET)

[1]All hexadecimal addresses. n = Apple slot#; x = n + 8.

[2]The items in parentheses are the functions performed by the Control Signals in the preprocessing system.

[3]See Tables 4.3 and 4.4 for addresses of particular registers for each channel.

$\overline{CS}$ line. Because the DMA card only uses channel #1 of the DMAC for transfers and channel #3 for data chaining (see Section 4.1.4), only the programming of the Control Registers of those channels is pertinent. The Control Signals are generated by decoding address lines A0 through A2 with a 74LS138 3-to-8 line decoder (U7). The decoder is enabled by the address line A3 and the $\overline{\text{Device}}$ $\overline{\text{Select}}$ line from the Apple. To ensure that no spurious addresses are decoded during a DMA transfer, the 74LS138 is disabled by the DGRNT signal.

Once the Control Registers are correctly loaded, a transfer request issued to the DMAC will initiate a DMA transfer. The DMA card allows requests from peripheral devices or the Apple itself. Generally, the request is issued by a peripheral device needing attention. This is done by pulling pin 15 on the ribbon cable LOW. This causes the TxRQ1 pin on the DMAC to go HIGH which constitutes a transfer request. The Apple issues a request through the Control Signal decoding logic (see Table 4.5). Reading or writing to the transfer request address sets the output of a 74LS74 flip-flop (U2a) HIGH. This also causes the TxRQ1 pin on the DMAC to go HIGH. The flip-flop is needed to hold the transfer request HIGH throughout the DMA transfer.

The DMA card was designed to use the MC6844 in the Halt Burst mode which means an entire block of data is transferred sequentially. However, the transfer may be suspended by withdrawing the transfer request on the TxRQ1 pin of the DMAC. The timing diagram of Figure 4.4 shows this situation. For the first byte of the Halt Burst mode the DMAC tests the TxRQ1 signal on the rising edge of the $\Phi 2$ DMA clock. In succeeding bytes the TxRQ1 signal is tested on the falling edge of $\Phi 2$ DMA, and data are transferred during the next $\Phi 2$ cycle if TxRQ1 is HIGH. After a peripheral device

issues the transfer request (ribbon cable pin 15, LOW), simply withdrawing the request will suspend the transfer. A peripheral device can also suspend the transfer when the Apple has issued the transfer request. This is also done with pin 15 on the ribbon cable. However, in this case, pulling pin 15 LOW suspends the transfer. This is a result of the exclusive-OR gate (U9) used to combine the Apple and the peripheral request lines.

After receiving a transfer request the DMAC responds with two outputs, Transfer Acknowledge A (TxAKA) and DMA Request Halt ($\overline{\text{DRQH}}$). One function of the TxAKA signal is to notify the peripheral device that a request has been received (ribbon cable pin 20). The TxAKA signal is also NOR-ed with DRQH (chips U3a, U8a and U8b) and the resulting signal is used to pull the $\overline{\text{DMA}}$ line on the Apple peripheral connector LOW, stopping the 6502 in the Apple. The TxAKA and $\overline{\text{DRQH}}$ signals are combined in order to hold the $\overline{\text{DMA}}$ line on the Apple LOW beyond the final DMA transfer cycle (see Figure 4.4).

Once the DMA halt request has been presented to the Apple, the DMAC expects a DMA Grant signal (DGRNT) to be returned. This must occur before the transfer begins. Because there is no bus available (or equivalent) connection in the Apple peripheral slot, DGRNT is synthesized from TxAKA using a 74LS74 flip-flop (U2b).

During the DMA transfer the Transfer Strobe line ($\overline{\text{TxSTB}}$, ribbon cable pin 19) acts as the Valid Memory Address (VMA) line. The completed DMA transfer is marked by the $\overline{\text{DEND}}$ signal (ribbon cable pin 18). This signal comes from the dual purpose pin $\overline{\text{IRQ}}/\overline{\text{DEND}}$ on the DMAC. The $\overline{\text{IRQ}}/\overline{\text{DEND}}$ and TxSTB signals are OR-ed (U3b) to produce $\overline{\text{DEND}}$. This prevents false signals arising from interrupt requests on the $\overline{\text{IRQ}}/\overline{\text{DEND}}$ DMAC pin. By examining the DMA end flag, bit 7 of the Channel Control Register of channel #1 (location \$Cn11, n = Apple slot #), the Apple may determine if the block DMA transfer

has been completed. Reading of the Channel Control Register resets the DMA end bit.

Except for the data lines, all outputs to the ribbon cable are buffered through either a 74LS367 or a 74LS368 6-input buffer. Other signals not mentioned previously that are available on the ribbon cable include: the Apple clock signals $\Phi 0$, $\Phi 1$, and Q3, the Control Signals $\overline{Y1}$ through $\overline{Y4}$, and the Apple Reset line $\overline{RES}$.

As mentioned in Section 4.1.4 on the MC6844, during a DMA transfer the DMAC only supplies the Apple RAM with addresses and controls the Apple read/write line. The peripheral device sending (or receiving) the data must place the data on the data bus within the restrictions of the Apple read/write timing (see Figure 4.4).

4.2 SLIPP Interface Unit

4.2.1 Introduction. The SLIPP unit was designed to interface the Apple microcomputer to the transmitting and receiving sections of the lidar system. The unit consists of a digital circuit and its required power supplies all mounted in a 5 1/2" x 9" x 12" box. The circuit is constructed on a Vector 3682-2 6.5" long card which plugs into an edge connector inside the box. Two extra edge connectors are also available in the box. Mounted on the back panel of the box are the following connectors: 1) a 34-pin ribbon cable connector for linking the Apple DMA circuit to the SLIPP unit, 2) four isolated BNC connectors labeled LCP, NIM, TRIG and AUX OUT. LCP is the Laser Command Pulse input (+5 V pulse), NIM is the photon pulse input from the discriminator (NIM standard: - 18 mA (-1 V), 12 nsec), TRIG is the laser trigger output (+5 V, 1 μsec pulse), and AUX OUT is an auxiliary pulse output (+5 V, 1 μsec pulse).

Appendix I contains the pinouts for the SLIPP circuit board and the

external ribbon cable. The location of the components on the circuit board is shown in Appendix II. Photographs of the SLIPP unit are shown in Figure 4.5. Figure 4.6 is the wiring schematic for the circuit.

4.2.2 Clock circuitry. The SLIPP clock circuitry is shown in the lower lefthand corner of Figure 4.6. The clock circuitry performs two functions: 1) inhibits the rest of the SLIPP photon counting circuitry until the Laser Command Pulse (LCP) is received; and 2) after receiving the LCP, provides the timing signals that drive the counting circuitry.

Two 74H74 positive-edge-triggered flip-flops are used to provide the enabling signals for the system. The first flip-flop (U12a) must be clocked by the user. This action enables the second flip-flop (U12b) which is then used to detect the LCP and provide the General Enable (GEN ENB) signal to the rest of the circuit. The first flip-flop is needed to ensure that the SLIPP system will not accidentally be enabled by a spurious LCP before the actual data run is to take place. Normally, the clocking of the first flip-flop is done by the pulse sent to trigger the laser (Control Signal $\overline{\text{Y1}}$ from the Apple DMA card). However, the Data Acquisition Enable Jumper, shown near the lower-center section of Figure 4.6, can be changed so that the user can clock the first flip-flop at his discretion (using Control Signal $\overline{\text{Y3}}$ from the Apple DMA card).

The master timing signal is supplied by a free-running 20 MHz oscillator. The 20 MHz signal is input into a 74162 decade counter (U23) divides the signal down to 2 MHz. However, the decade counter must be enabled by the GEN ENB signal before outputting the 2 MHz signal. In this way, no timing signals are supplied to the rest of the counting circuitry until the LCP has been received. The decade counter allows only up to 50 nsec skew time between the LCP and the beginning of the first 2 MHz clock cycle.

(a)

(b)

(c)

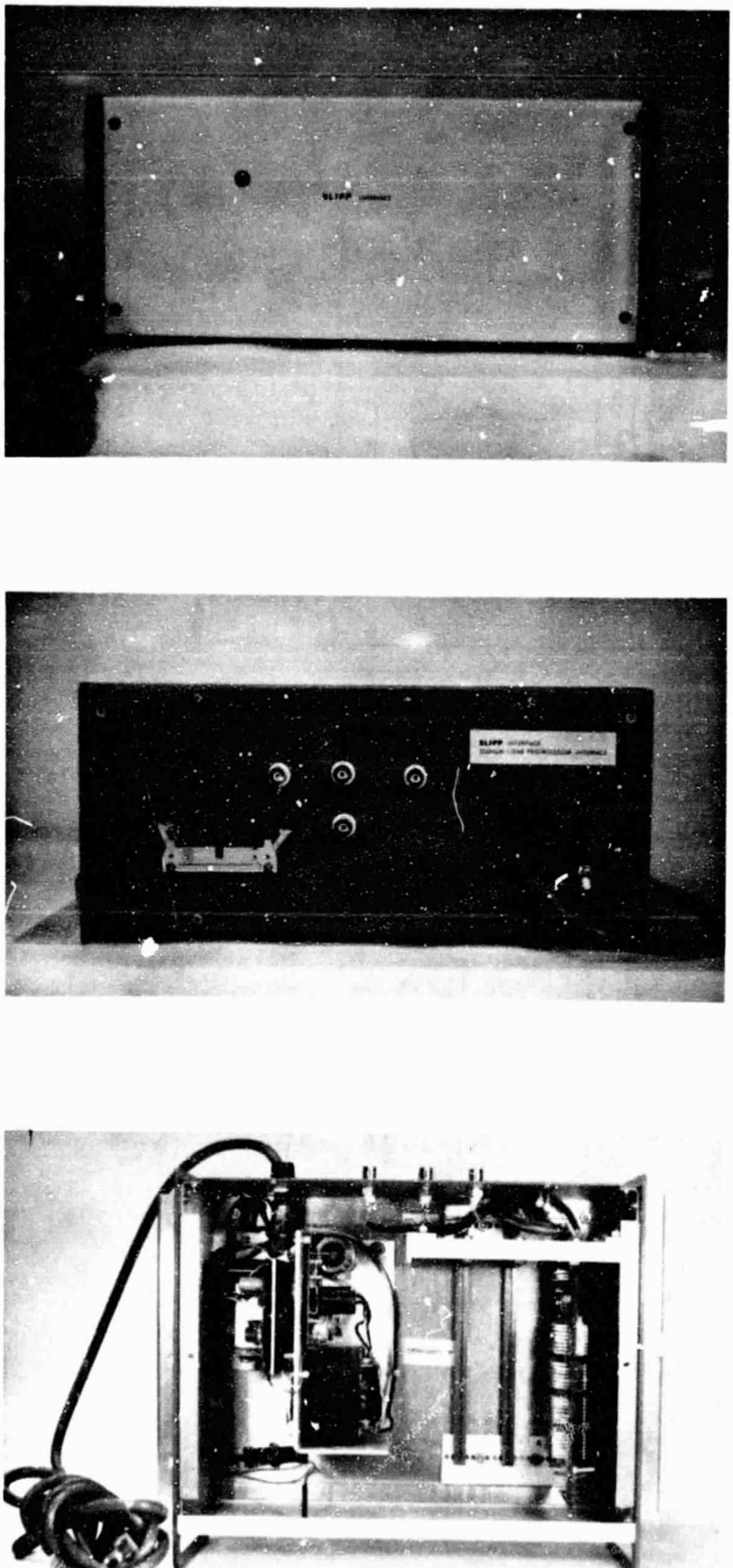


Figure 4.5 Photographs of the SLIPP unit: (a) front panel, (b) back panel, and (c) top view of the open cabinet.

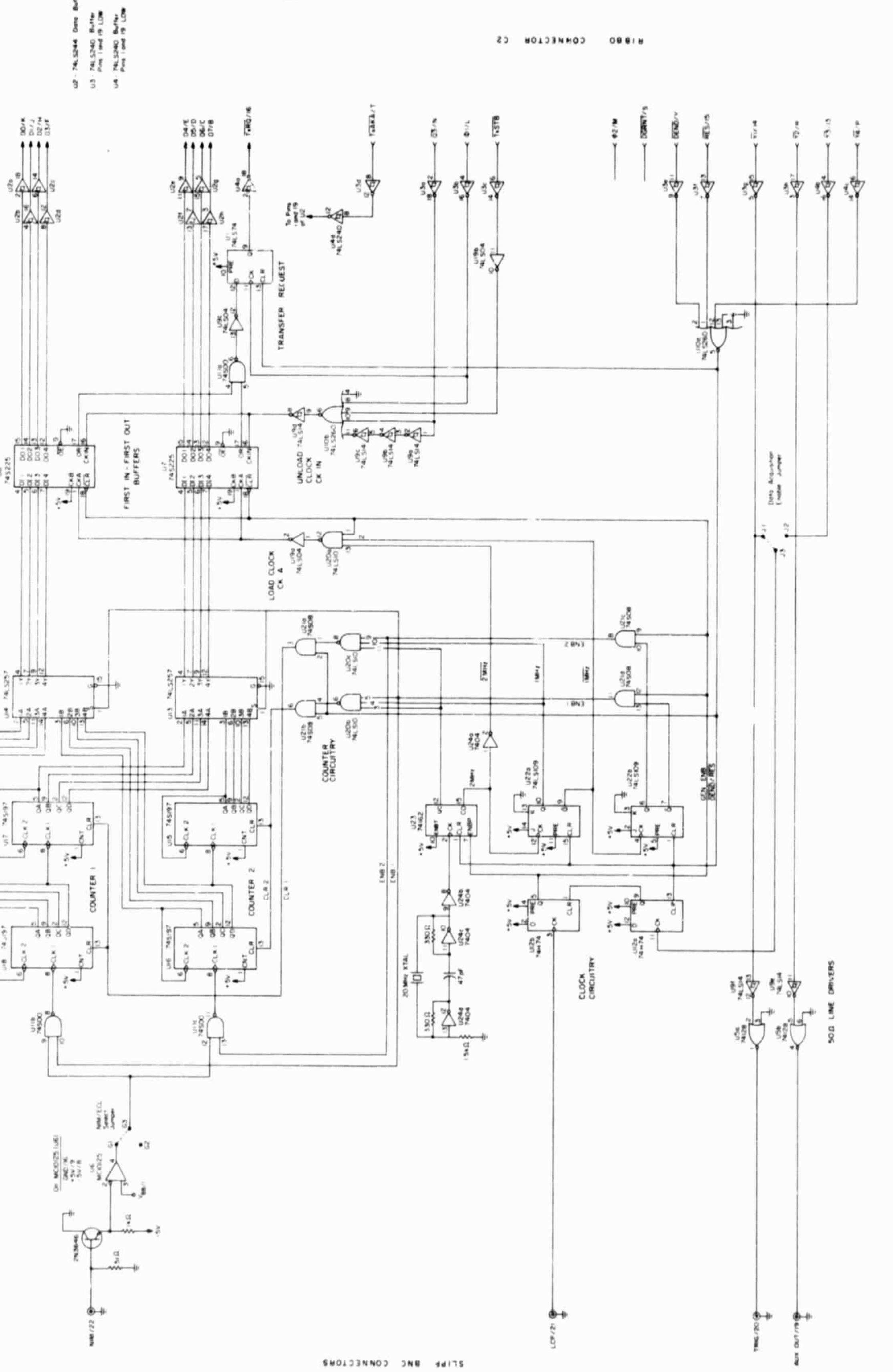


Figure 4.6 SLIPP unit circuitry.

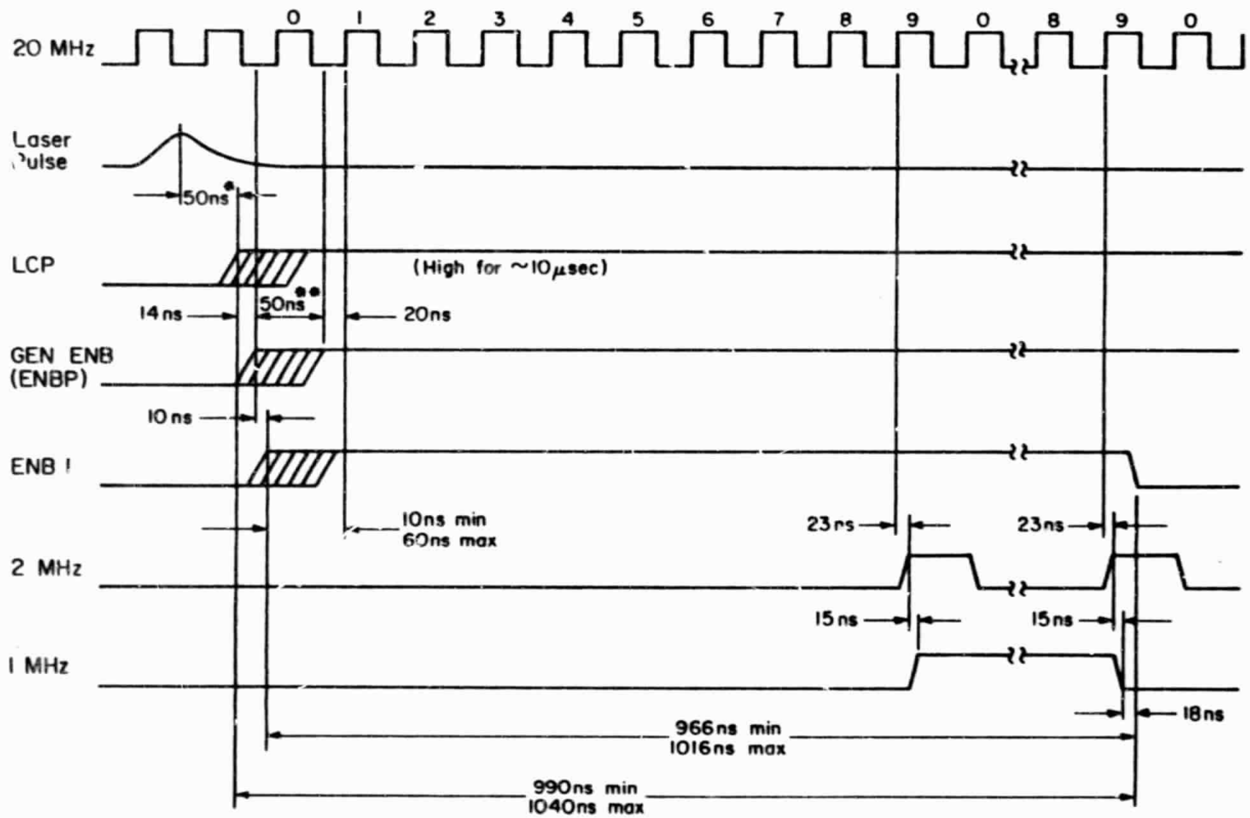
After the decade counter is enabled, two 74LS109 positive-edge-triggered flip-flops (U22a and U22b) are used to divide the 2 MHz signal down to 1 MHz and 0.5 MHz. The inverted signals $\overline{\text{2 MHz}}$, $\overline{\text{1 MHz}}$, and $\overline{\text{0.5 MHz}}$ are also generated by the circuitry. The 0.5 MHz and $\overline{\text{0.5 MHz}}$ signals are labeled ENB 1 and ENB 2, respectively. These signals are used to select the toggling photon counters discussed in Section 4.2.3. Two 74S08 NAND gates (U21c and U21d) are used to hold both ENB1 and ENB 2 LOW while the GEN ENB signal is inactive (LOW).

Figure 4.7 shows the timing relations for various clock circuitry signals immediately following a laser shot. The times noted on the diagram were calculated using typical propagation delay values for the particular chips involved.

4.2.3 <u>Counting circuitry</u>. The counting circuitry is shown in the upper left-hand corner of Figure 4.6. The circuitry takes the NIM standard pulses from the lidar system discriminator and counts them in consecutive 1 μsec intervals.

The counters used in the circuitry are TTL binary counters so it is necessary to shift the NIM pulses to TTL levels. This is done in two stages. First, a 2N3646 transistor configured as an emitter-follower shifts the NIM pulses to emitter-coupled logic levels (ECL: -0.9V = "0", -1.7 V = "1"). A Motorola MC10125 ECL to TTL converter chip (U6) is then used to obtain positive TTL pulses. A NIM/ECL select jumper has been provided in the circuit for possible future upgrade to ECL l[illegible] inputs.

Two 8-bit counters in a toggling configuration are used in the circuit to obtain the photon counts. At any given 1 μsec interval during a data run, one counter is counting pulses while the contents of the other counter,



*The laser pulse is actually about 2 μsec in duration. The 50 nsec time shown is an estimate of the delay in the laser pulse detector from the time the laser pulse first triggers the detector.

**50-nsec skew time.

Figure 4.7 SLIPP unit clock circuitry enable timing.

obtained during the previous interval, are being placed in Apple memory. Each counter is composed of two cascaded 74S197 4-bit binary counters (counter #1: chips U18, U17; counter #2: chips U16, U15).

The positive TTL photon pulses are input to the counters through two 74S00 NAND gates (U11b and U11c). These gates use the ENB 1 and ENB 2 signals from the clock circuitry to section the pulses into 1 μsec intervals and select the counter to receive the pulses. The gates also invert the photon pulses for input to the 74S197 counters.

During the inactive (non-counting) cycle of a counter, two actions are performed. First, the contents of the counter are stored; and second, the counter is cleared. Two 74LS257 quad multiplexer chips (U13, U14) select the counter output to be stored. The ENB 1 signal is used to drive the select input on the chips. The multiplexers can be thought of as operating 180 degrees out of phase with the input NAND gates (U11b, U11c). The output of the multiplexers is clocked into the Apple interface circuitry described in the next section. The Qc (3rd bit) output of the decade counter in the clock circuitry (U23) is used to clear the counters. Two 3-input NAND gates (U20b, U20c) and two AND gates (U21a, U21b) determine when and which counter to clear.

The important timing signals for the counting circuitry are shown in Figure 4.8. The Data Load Clock (CK A) signal in the figure is described in the next section.

4.2.4 <u>Apple Interfacing Logic</u>. The logic interfacing the SLIPP unit and the Apple microcomputer allows the following functions to be performed: 1) the resetting of the SLIPP circuitry, 2) the firing of the laser and the enabling of the SLIPP counting circuitry, and 3) the DMA data transfer from the SLIPP unit to the Apple. The interfacing logic is generally shown in

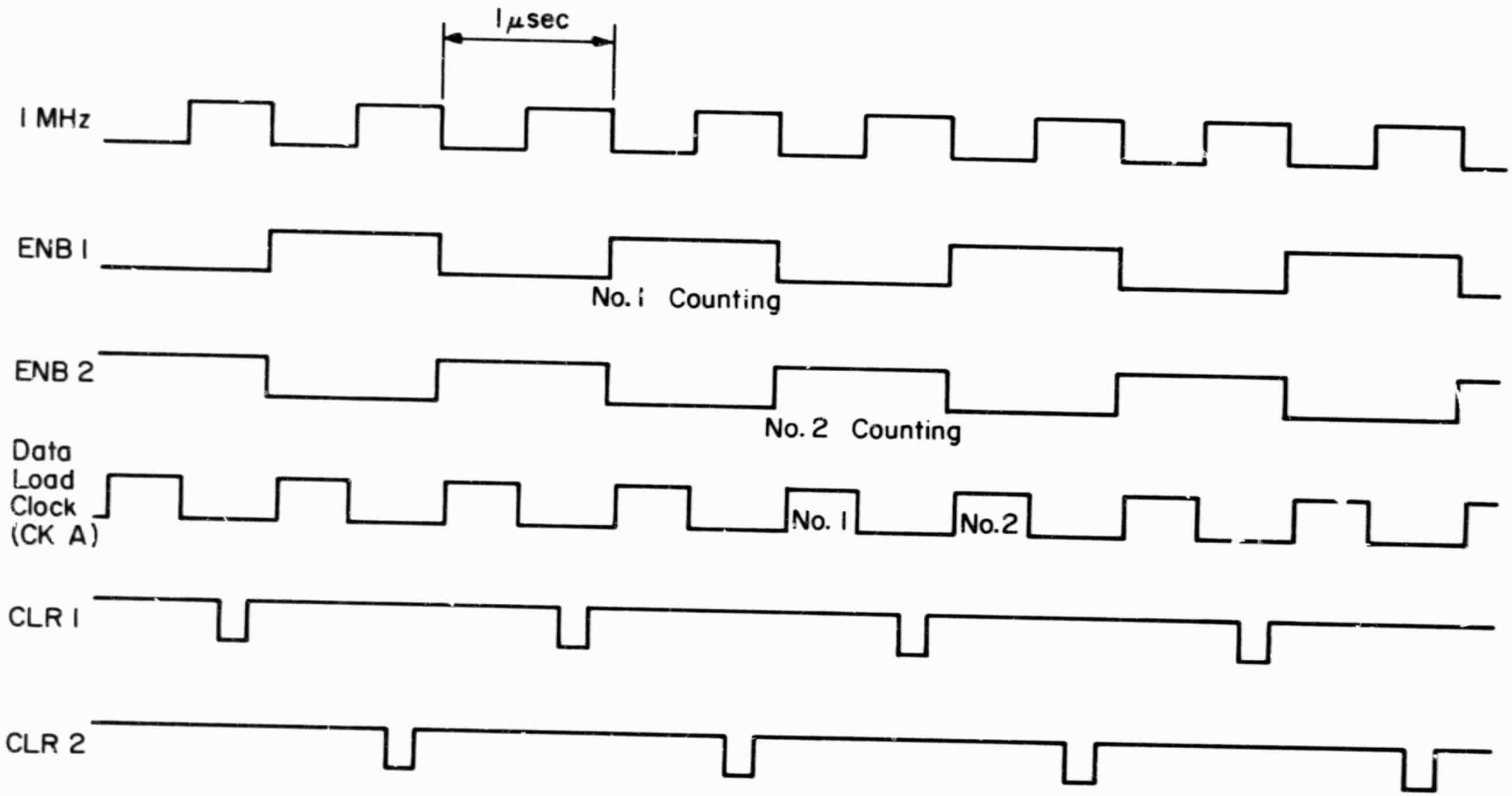


Figure 4.8 SLIPP unit counting circuitry timing.

the SLIPP unit to the Apple. The interfacing logic is generally shown in the right-hand side of Figure 4.6.

Three different signals from the Apple DMA card will reset the SLIPP circuitry. The signals are the Reset signal ($\overline{\mathrm{RES}}$) which is connected to the Apple reset line, the $\overline{\mathrm{Y4}}$ Control Signal, and the DMA End ($\overline{\mathrm{DEND}}$) signal which comes at the end of a DMA transfer. The three signals are input to a 74LS260 5-input NOR gate (U10a) which is shown in the lower right-hand corner of Figure 4.6. The output of the NOR gate is used to reset the clock circuitry flip-flops discussed in Section 4.2.2, clear the counters discussed in Section 4.2.3, and reset the transfer request flip-flop which will be discussed further in this section.

The $\overline{\mathrm{Y1}}$ Control Signal from the Apple DMA card is normally used to trigger the laser. The $\overline{\mathrm{Y1}}$ signal on the ribbon connector (C2) is input to a 74128 50-Ohm line driver (U5a) shown in the lower left-hand corner of Figure 4.6. The line driver output is connected to the TRIG BNC connector on the back panel of the SLIPP box. Control Signal $\overline{\mathrm{Y1}}$ is also used to enable the clock circuitry flip-flops. A second line driver (U5b) is used to drive the Auxiliary Output (AUX OUT), and Control Signal $\overline{\mathrm{Y2}}$ is used to pulse the output. More details on the laser firing and the circuit enabling are discussed in Section 4.2.2 on the SLIPP clock circuitry.

As mentioned in Section 4.1.2 on Apple Timing, the Apple and the SLIPP unit operate asynchronously. The SLIPP unit photon counters during a data run output data at a rate of 1.0 Mbytes/sec while the Apple DMA circuitry, operating at the Apple $\Phi 0$ clock rate, accepts data at a 1.023 Mbytes/sec rate. To transfer smoothly, the data bytes from the SLIPP unit to the Apple a First-In/First-Out buffer technique was used. The buffer circuitry is shown in the upper right-hand corner of Figure 4.6 and is sectioned into the following parts: the First-In/First-Out buffers, the Load Clock (CK A), the

Unload Clock (CK IN), and the Transfer Request circuit.

Two 74S225 16 x 5 asynchronous First-In/First-Out (FIFO) buffer chips (U7 and U8) are the heart of the buffer system. Data bytes from the SLIPP unit's counting circuitry are clocked into the FIFOs with the Load Clock (CK A) circuitry. The Unload Clock (CK IN) circuitry uses the Apple Clock signals Q3 and $\Phi 1$ and the Apple DMA signal $\overline{TxSTB}$ to clock data out of the FIFOs to the Apple RAM.

Because the Apple DMA circuit transfers data bytes faster than the SLIPP unit can supply them, the DMA circuit must be signaled periodically to wait during a data run. This is effected through the Transfer Request circuitry. The Transfer Request circuit uses the Output Ready (OR) lines on the FIFOs. These lines are active (HIGH) whenever a valid byte is in the FIFO's output register. The OR lines from the two FIFOs are AND-ed together (U11a and U19c) and the resulting signal is input to a 74LS74 positive-edge-triggered D-type flip-flop (U1). The flip-flop essentially tests the composite OR signal on the rising edge of the Apple $\Phi 0$ clock. If the OR signal is HIGH when tested, the transfer request to the Apple DMA circuit becomes (or remains) active. If the FIFOs output buffers are not ready when the OR signal is tested (OR signal LOW), the transfer request to the DMA circuit is withdrawn. This will halt the DMA process until the transfer request is restored (normally the next rising edge of $\Phi 0$).

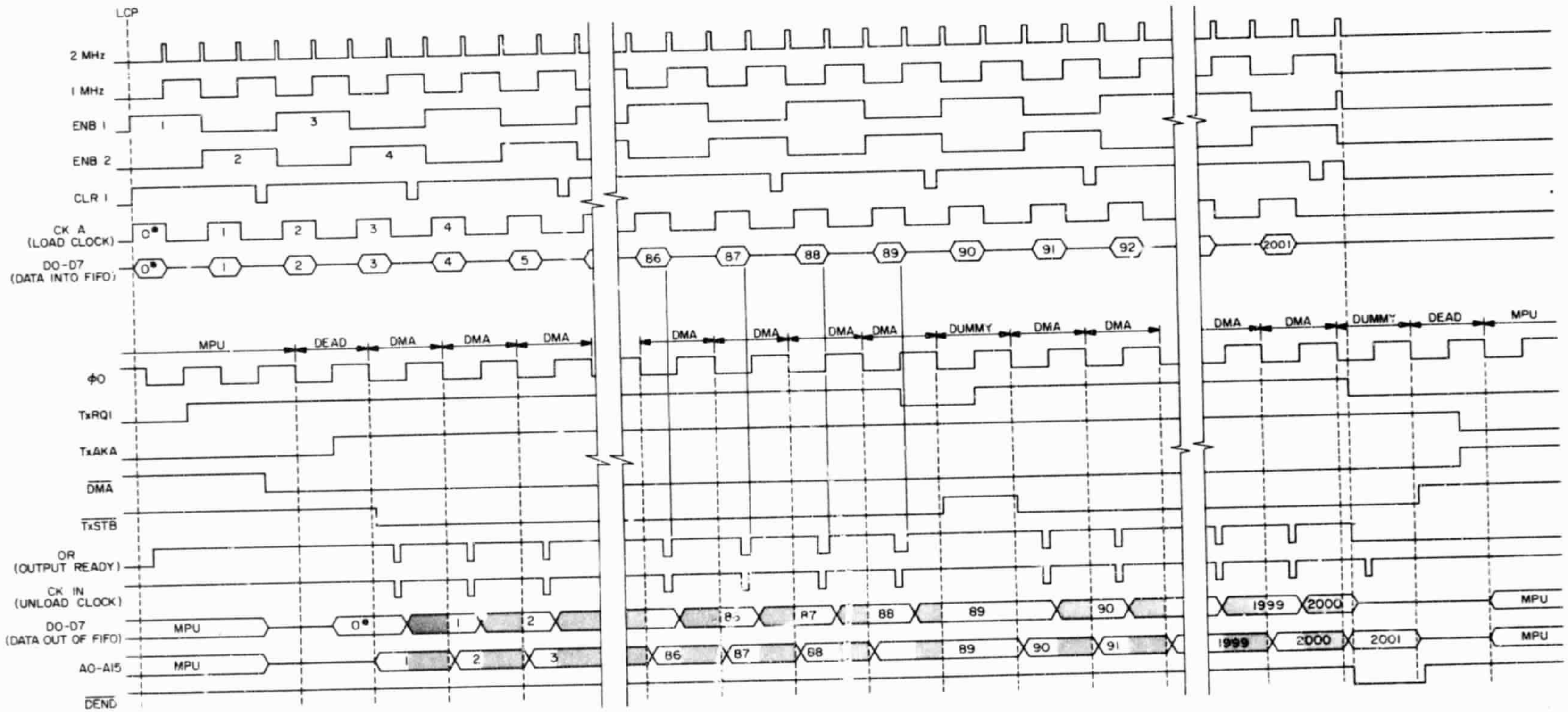
All lines connected to the 34-pin Apple-SLIPP ribbon cable are buffered with either inverting or non-inverting line drivers/receivers. The buffer chips consist of two 74LS240 octal inverting buffers (U3 and U4) and one 74LS244 octal non-inverting buffer (U2). The 74LS244 three-state buffers are used to drive the data lines D0-D7 and are activated by the DMA signal

$\overline{\text{TxAkA}}$ during a DMA transfer.

Figure 4.9 is a timing diagram for various SLIPP unit and Apple signals during the data collection for one laser shot. The signals in the upper half of the figure are SLIPP unit signals while Apple signals are shown in the lower half. The left-hand section of the diagram shows the beginning of the data collection. The middle section shows an instance where the Apple DMA transfer is suspended and the right-hand section shows the end of the data collection.

One consequence of the interface logic design described above is that the number of range bins collected by the SLIPP unit is set by the programming of the MC6844 DMAC Byte Count register on the Apple DMA card. If the Byte Count register is programmed for a transfer of N bytes, the SLIPP unit will collect N-1 range bins. The minus one arises from the fact that during the last byte of the DMA transfer the SLIPP unit FIFOs are being reset.

4.2.5 Power supplies. Two power supplies mounted in the SLIPP box supply +5 V and -5 V to the SLIPP circuits (Figure 4.10). A Power One C5 - 6 Amp supply provides +5 V and a Power One HA5 - 1.2 Amp supply is connected as a -5 V supply. The DC ground on the supplies is referenced to the Apple logic ground through the SLIPP-Apple ribbon cable. The AC input to the supplies is fused at 1.5 A and a switch located on the back panel of the SLIPP box turns on the supplies.



• First byte (0) is not valid data and it is not recorded.

Time at which data and addresses are stable for DMA byte transfer

Figure 4.9 SLIPP unit and Apple timing signals during data collection.

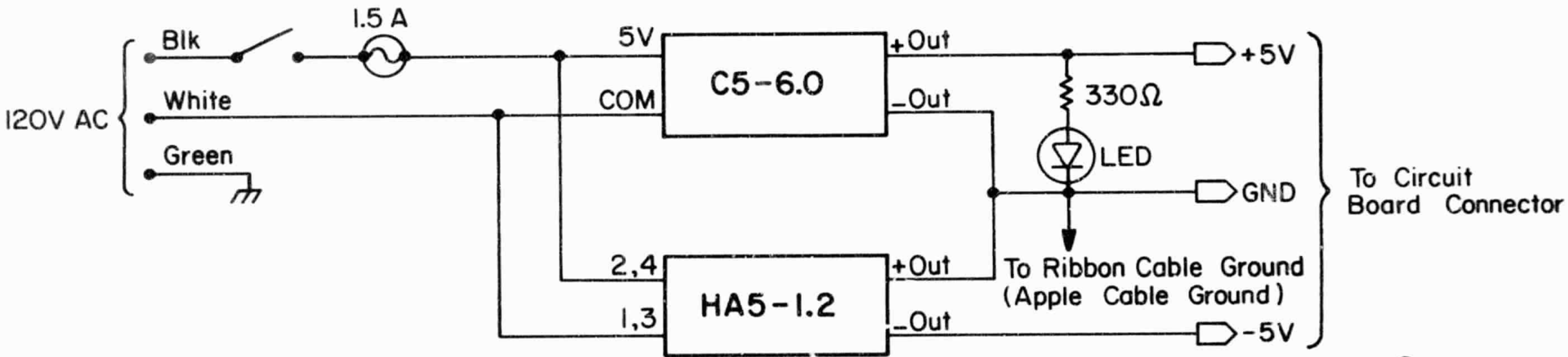


Figure 4.10 SLIPP unit power supplies.

5. SOFTWARE DESCRIPTION

5.1 Introduction

Three software routines were written for use with the preprocessing system. Two of the routines are run during data collection. They are SLPAPP.OBJ which drives the Apple in the preprocessing system and FZZ.SAV which drives the LSI-11. The third routine CONVRT.SAV is run on the LSI-11 after data collection is complete. CONVRT.SAV takes the binary data files created on a floppy disk during data collection and converts them to ASCII files. This is a necessary step before transferring the data files to the University of Illinois CYBER computer for further processing. The Apple program was written in 6502 machine language with the Apple 6502 Assembler/Editor on the Apple Tool Kit disk. The LSI-11 programs contain both Fortran and Macro-11 subroutines written under the RT-11 Version 4 operating system.

A general discussion of the data collection software is contained in Section 5.2. The routines used by the Apple and the LSI-11 for communications between each other are an integral part of the collection software. The communication routines for both computers are quite similar and are presented in Section 5.3. Section 5.4 contains notes on some of the options available in the collection software. Section 5.5 is a discussion of the data file conversion software. All the program listings are presented in Appendix III.

5.2 Data Collection Software

5.2.1 Apple routines. The file SLPAPP.OBJ, containing the Apple data collection software, is sectioned into five parts which are labeled: the Main Program Loop, the Apple Receiver, the Apple Sender, Data Run, and Printing Routines. The Apple Receiver and Sender sections handle the Apple

side of the Apple-LSI-11 communications. These routines are discussed in Section 5.3 on Apple and LSI-11 communications. The Printing Routines are a set of subroutines which display messages on the Apple monitor. Details of the Main Program Loop and the Data Run sections are discussed below.

Part (a) of Figure 5.1 shows a flowchart of the Main Program Loop section. When the file SLPAPP.OBJ is run, execution begins at this section. First, a keyboard input routine is loaded. This allows keystrokes on the keyboard to be accepted by the Apple. Next, a heading is displayed on the monitor and the program waits for a keypress before continuing. After the keypress the CCS serial card (for communication with the LSI-11) and the interrupt and byte input vectors (INTV and STATE) are initialized for use with the Apple receiving code. Finally, the interrupt disable bit is cleared, the message "IDLE" is displayed on the monitor, and the routine begins the idle wait loop. Presently, the idle loop is a simple waiting loop but in the future the loop can be replaced with a background routine such as a laser tuning algorithm.

The Data Run section of the program is actually a subroutine labeled DATRUN which is called by the Apple Receiver routine after receiving the "data run" frame. A flowchart of DATRUN is shown in part (b) of Figure 5.1. Before DATRUN is called the two variables REPNUM and MSHOTS must be loaded. REPNUM is used by DATRUN to set the laser pulse repetition rate while the desired number of laser shots per profile is contained in MSHOTS. The values to be loaded into the two variables are sent from the LSI-11 to the Apple within a "commands" communication frame.

Once called, DATRUN begins by displaying the message "TAKING DATA" on the Apple monitor. Next, the laser shot counter TSHOT is loaded with the value contained in MSHOTS and the MC6844 DMAC registers are loaded. The

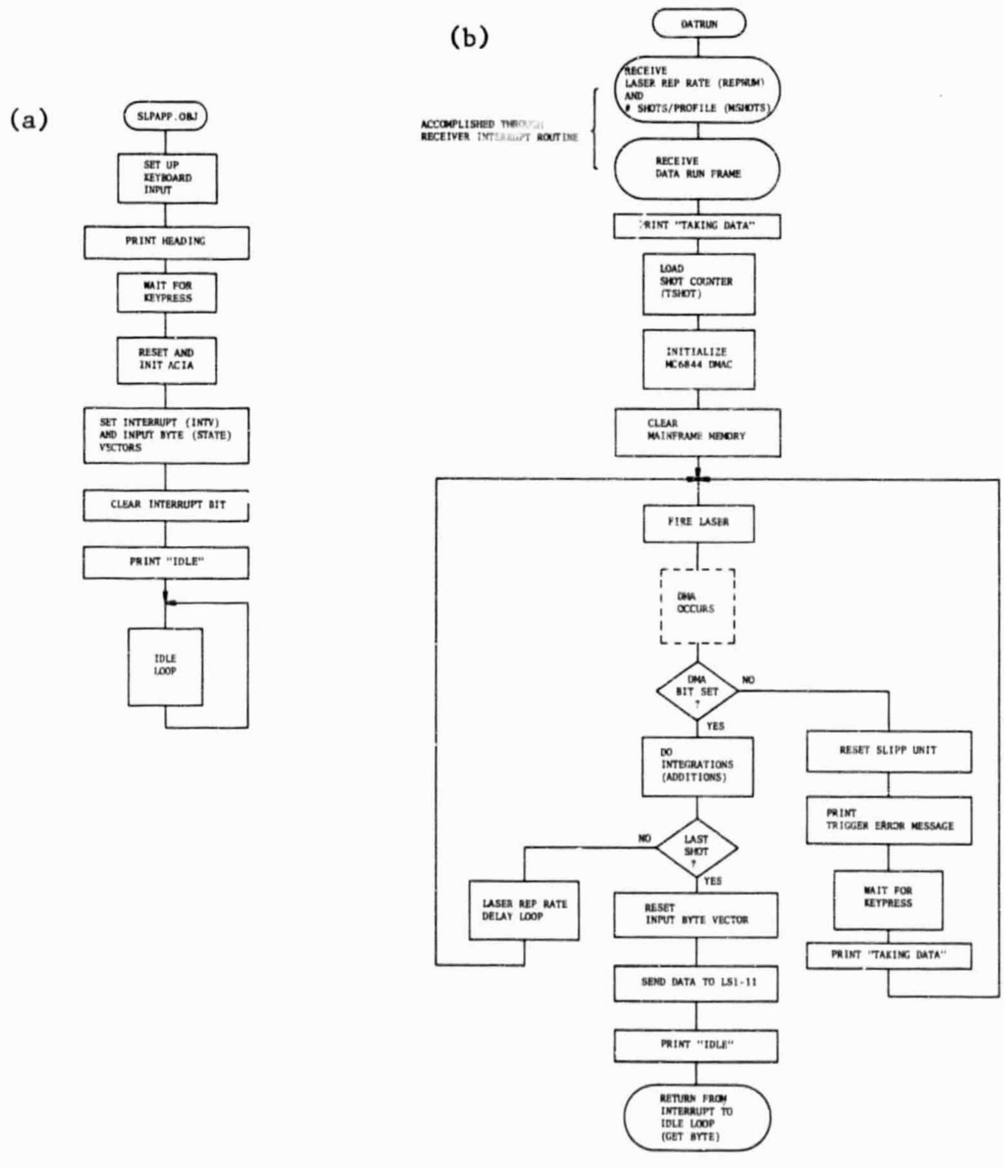


Figure 5.1 Flowchart of (a) SLPAPP Main Program Loop and (b) SLPAPP Data Run sections.

mainframe memory (the block of memory used to store the profile integration sum) is also initialized.

After the initializations the profile collection begins. The laser and the SLIPP unit are triggered by accessing the trigger address (Control Signal Y1). The routine execution is suspended during the range bin collection and DMA transfer. When the execution resumes, a status bit in the MC6844 DMAC on the Apple DMA card is tested. If the bit is not set the DMA transfer never occurred and control jumps to an error routine. With the bit set, the Apple integrates (adds) the new range bin counts into the profile integration sum in the mainframe memory. The 16-bit addition routine used causes the high order and low order bytes of the 16-bit data words to be stored in separate blocks of memory. This algorithm was selected because of its fast execution time. After the integrations, the shot counter TSHOT is decremented and tested for a zero value. If more laser shots are required for the profile, the routine executes a delay loop and then returns to fire the next laser shot.

The delay loop is required in order to regulate the laser pulse repetition rate. The value stored in the variable REPNUM is used to set the length of the delay. An equation taking into account the number of Apple machine language instructions between successive laser shots, the desired pulse repetition rate, and the structure of the delay loop code is used by the LSI-11 to solve for the value to be stored in REPNUM. REPNUM is a one-byte location so values ranging from 0 to 255 can be assigned to it. As mentioned previously, the REPNUM value is sent from the LSI-11 to the Apple within a "commands" frame.

After the data collection and integration are completed for the last laser shot of a profile, the data are sent to the LSI-11 computer within a

"data" communication frame. (Before sending the "data" frame, the input byte vector STATE must be reset to point to the beginning of the receiving code. This allows the "acknowledge" communication frame sent by the LSI-11, verifying the successful receipt of the data, to be properly interpreted.) Finally, the "IDLE" message is displayed and a return from interrupt is executed to reenter the idle wait loop in the Main Program Loop.

5.2.2 LSI-11 routines. The LSI-11 data collection software is comprised of twelve Fortran and Macro-11 files which are compiled and linked into one executable file labeled FZZ.SAV. The twelve files are: FZZ.FOR, EXPPAR.FOR, CSTTUS.FOR, LAALN.FOR, ALNRTN.FOR, DATRUN.FOR, EXMPRF.FOR, DISCAL.FOR, RCVER.MAC, SENDER.MAC, DISPLY.MAC, and HDUMP.MAC. In order to decrease file manipulation problems, all the compiled versions of the files (except for FZZ.OBJ) were placed in the library file SLPLIB.OBJ. Figure 5.2 shows a general flowchart for the collection program FZZ.SAV. Descriptions of each of the twelve files in the collection program are presented below.

FZZ is the main program file. All variables and constants for the collection software are initialized by this file. FZZ also initializes the serial port for Apple-LSI-11 communications by calling the subroutine INITR (INITR is contained in the file RCVER). The LSI-11 Job Status Word is set for "no terminal wait state." This allows the use of the Fortran input function ITTINR in the following manner: A character is transferred from the console terminal to the user's program if a character is present; but program execution continues whether a character is present or not (see Section 5.4 for the use of this option). After the initializations, FZZ displays the main collection software menu. Selection of one of the seven available options in the menu results in a call to a particular subroutine. The first six options (1-6) call the subroutines EXPPAR, CSTTUS, LAALN,

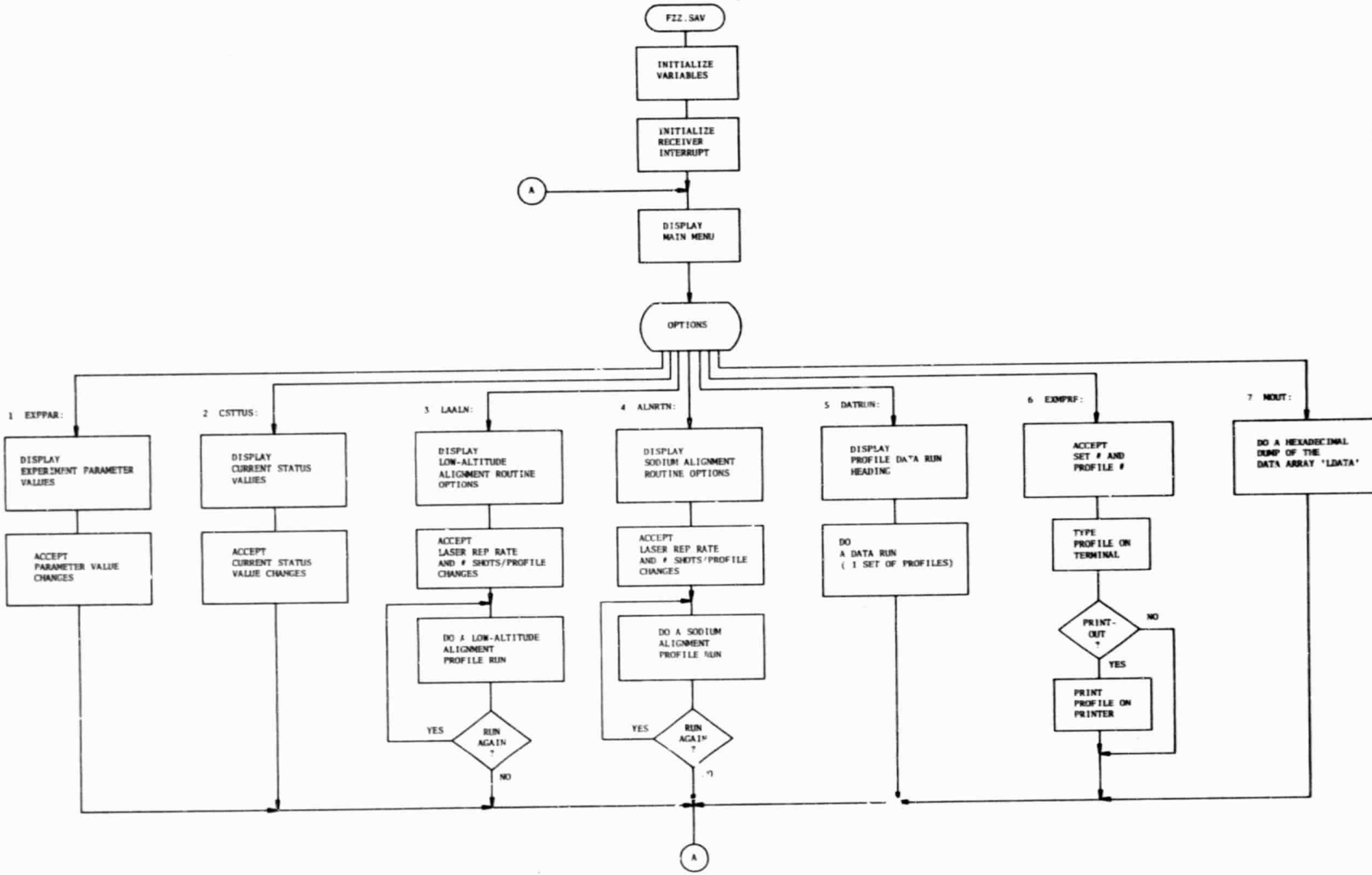


Figure 5.2 Flowchart of LSI-11 main collection program FZZ.

ALNRTN, DATRUN, and EXMPRF, respectively. Option 7 is not actually displayed in the menu but it is a viable option. Selecting option 7 results in a call to the subroutine MOUT which is contained in the file RCVER.

EXPPAR displays the experiment parameters and allows them to be changed by the operator. The parameters are used by the two routines which obtain sodium data: ALNRTN and DATRUN. A brief description of each of the parameters follows:

#Sets - number of data sets of profiles to be collected before returning to the main menu. (Presently, this is a dummy variable and is not utilized by the software.)

#Profiles Per Set - number of profiles to be placed in a data set.

#Laser Shots Per Profile - number of laser shots per profile.

Inter-Profile Delay - extra delay time desired between the collection of successive profiles (seconds).

Elevation Angle - angle between horizontal and receiving telescope line-of-sight (degrees).

Base Altitude - altitude of the lidar system in reference to the earth's surface (feet and kilometers).

Altitude Range of Data - altitude range of sodium data to be stored on a floppy disk (kilometers).

Range Bins - the set of range bins to be stored on a floppy disk.

The Elevation Angle, Base Altitude, Altitude Range of Data, and Range Bins parameters are all related through a set of range equations, and changing one of the parameters results in a recalculation of the others (see the EXPPAR listing in Appendix III.3 for details).

CSTTUS displays a table of values that reflect the current status of the experiment. Included in the table are: the current profile and set

numbers (the numbers by which the next profile collected will be identified), the desired number of laser shots per profile, and the sodium values as calculated by the subroutine DISCAL for the last recorded profile. CSTTUS also allows the operator to change the current profile and set numbers.

LAALN directs a low-altitude data collection run for lidar system alignment purposes. After being called, the first action of LAALN is to allow the operator to select the laser repetition rate and the number of laser shots needed for each low-altitude profile. Next, the subroutine requests the collection of one profile and then displays the completed profile range bin counts for bins 1 through 600 (corresponding to a range of 0 to 90 km).

The steps followed by LAALN to obtain the profile are similar to those described in the paragraph on DATRUN, except it is important to note that the profile is not permanently saved on a floppy disk. After the counts are displayed the operator is prompted for a decision on whether to run the routine again or to return to the main menu. The low-altitude counts observed with the help of this routine are in general due to Rayleigh scattering. By using the routine in an iterative fashion the critical alignment of the laser beam and the receiving telescope field-of-view can be accomplished.

ALNRTN directs a sodium data collection run for lidar system alignment purposes. ALNRTN has exactly the same format as LAALN, the low-altitude alignment routine, except that each profile collected is examined for sodium returns. ALNRTN calls the subroutine DISCAL to provide a summary of the sodium counts. Also, ALNRTN uses the two experiment parameters Base Altitude and Elevation Angle as set in the subroutine EXPPAR. The two parameters are necessary for the selection of the range bins that should

contain sodium counts (see the paragraph on DISCAL). ALNRTN is helpful when making final laser tuning and laser-telescope alignment adjustments.

DATRUN directs the collection of a set of profiles with the details of the collection process set by the experiment parameters of the subroutine EXPPAR. Initially, DATRUN displays the storage space (blocks) needed on the floppy disk to save the forthcoming set of profiles. Also displayed is the record length (double words) of each profile in the set. These values are provided to help keep track of the space remaining on the data floppy disk. Along with the block length and record size values, the operator is prompted to start the data run. Once the run begins, DATRUN updates the file name to be used on the data floppy disk for identifying the forthcoming set of profiles. Also, the range parameters required by DISCAL for the sodium count summary are calculated. Values for the two variables REPNUM and MSHOTS are also determined. These variables are required by the Apple data collection software and are sent from the LSI-11 to the Apple within a "commands" communication frame. A "data run" frame sent from the LSI-11 to the Apple requests the collection of a profile. The setting of the flag DFLAG alerts the routine that the profile data has been collected and received successfully by the LSI-11. An error in the transmission of the profile data from the Apple to the LSI-11 results in the setting of the flag ERRFLG, and program control is returned to the main software collection menu. DATRUN calls the subroutine DISCAL to provide a summary of the sodium counts and the profile is saved on the data floppy disk. If more profiles are required to complete a set, the profile number is updated and collection begins again. A few details of the subroutine DATRUN are also discussed in Section 5.4 on Software Collection Options.

EXMPRF allows the operator to examine the range bin counts of profiles

that have previously been collected and stored on a floppy disk. EXMPRF prompts the operator to enter the set and profile numbers of the profile to be examined. The subroutine expects the requested data to be on a floppy disk in the disk drive designated as the data storage drive (see Section 5.4). The range bin counts are displayed on the console terminal and a printout of the counts can be obtained by responding to the prompt at the end of the terminal display.

DISCAL is called by the routines ALNRTN and DATRUN to provide the operator with a summary on the console terminal of the sodium counts in a profile. DISCAL also provides a printout of the sodium count summary for the routine DATRUN. The flag RUNFLG is used by DISCAL to determine whether ALNRTN or DATRUN is requesting its services. DISCAL expects the profile data to be recorded in the array LDATA and values for the following range parameters must be determined (by the calling routine) as they are necessary for the sodium count calculations:

B30 - 30-km bin pointer. (The number of the range bin that corresponds to an altitude of 30 km.)

B60 - 60-km bin pointer.

S20 - the number of range bins required for a collection range of 20 km.

DISCAL also uses the experiment parameters accessed through the subroutine EXPPAR. Below are descriptions of the quantities of the sodium counts displayed by DISCAL:

Detected Photons - the sum of the counts in the bins for the designated ranges (at 30 km, 60-80 km, 80-100 km, and 100-120 km).

Total Signal Photons - the detected counts in the 80-100 range minus the counts in the 60-80 km range.

Signal Photons Per Shot - the Total Signal Photons divided by the laser shots per profile.

Column Abundance Ratio - the Total Signal Photons divided by the difference of the counts in the 30-km bin and the average counts in a bin in the 60-80 km range.

RCVER and SENDER handle the LSI-11 side of the Apple-LSI-11 serial communications and are discussed in detail in Section 5.3. The RCVER file also contains the subroutines INITR and MOUT. When called, INITR initializes the program counter and status word vectors for the serial port used for the Apple-LSI-11 communications. Also initialized is the input byte vector STATE (see Section 5.3.5). The subroutine MOUT, with the use of the file HDUMP, displays on the terminal in hexadecimal form the contents of the data array LDATA.

The DISPLY file contains a set of subroutines which are called in order to enable display options available on the console terminal. The subroutines include: CLRSCN - clear screen, FORSCN - inverse or "highlighted" video, BAKSCN - normal video, and BELSCN - ring the bell. The DISPLY file listing presented in Appendix III.12 shows display subroutines designed for use with the DEC VT100 family of terminals. However, the display subroutines can be used with other types of terminals (for example, the Hazeltine 1500) by changing the terminal command codes transmitted by the subroutines to those command codes recognized by the particular terminal.

HDUMP displays a section of memory on the console terminal in hexadecimal form. HDUMP must be given the starting memory address and the byte count of the section to be dumped.

5.3 Data Collection Communication Routines

5.3.1 Introduction. During a data collection run the Apple and the

LSI-11 communicate with each other over an RS-232 standard asynchronous serial link at 9600 baud. Sequential streams of bytes, often referred to as "frames" or "packets," are used to encode the commands or data that are sent between computers. The particular Apple and LSI-11 frames are discussed in Section 5.3.3 on Protocol and Sections 5.3.4 and 5.3.5 on the sending and receiving program structures.

The frame sending sections of the Apple and LSI-11 data collection programs are essentially a set of subroutines which send the desired messages. The receiving sections of the collection programs are interrupt routines which receive and interpret the frames. Each byte received causes an interrupt which gives program control to the receiving section of code and the incoming byte is checked if it is a marker or saved if it is data. Once a complete frame is received, the receiving section of code must interpret the frame and carry out the appropriate action. This interrupt structure was developed so the computers could run background programs during "free" periods of time in the collection process. An example of a background program might be a laser tuning algorithm on the Apple which runs while the LSI-11 is busy storing and doing a printout on the current data profile.

The serial communications link was selected over other types of links (for example, a parallel link) because it was realized that during experiments the Apple and the LSI-11 might be separated by a substantial distance (20-30 feet) and it was felt that the serial link would be less susceptible to noise problems. Many of the ideas used in the design of the communications software are presented in the article "Build an Intercomputer Data Link," by Wingfield (Byte, April 1981).

5.3.2 Serial peripheral cards. Two interface cards are used for the serial communications. A California Computer Systems (CCS) model 7710A asynchronous serial interface card is used in the Apple and a DEC DLV11-J four port asynchronous interface is used in the LSI-11.

The CCS card is designed to be used in any of the Apple peripheral slots 1 through 7. The card has one channel and uses the Apple I/O addresses as shown in Table 5.1. A DB 25-pin female connector is provided on the card for serial input and output. Details on the use of the card are available in the CCS Model 7710A Owner's Manual. The preprocessing software presented in this report was written for the CCS card operating in Apple slot 2.

The DEC DLV11-J interface card mounts into the LSI-11 computer backplane. The DLV11-J has four channels with the register and vector addresses shown in Table 5.2. Each channel has a 10(2x5) pin connector for serial I/O purposes. The DLV11-J is described in detail in the DEC Microcomputer Interfaces Handbook [1980]. In the lidar system the DLV11-J is not only used for the Apple-LSI-11 communications but also for the console terminal and the line printer input and output. The channel assignments for the lidar system are:

Channel 0 = Apple-LSI-11 communications

Channel 1 = open

Channel 2 = line printer

Channel 3 = console terminal

Figure 5.3 shows the connections for the cable between the Apple CCS card and the LSI-11 DLV11-J.

5.3.3 Communication protocol. Computer protocols are the forms that are established as appropriate and acceptable in communication between

TABLE 5.1 APPLE CCS SERIAL CARD I/O LOCATIONS

ADDRESS (HEX)	REGISTER
C0x0 (Write)	COMMAND
C0x0 (Read)	STATUS
C0x1 (Write)	TRANSMIT DATA
C0x1 (Read)	RECEIVE DATA

TABLE 5.2 LSI-11 DLV11-J SERIAL INTERFACE I/O LOCATIONS

ADDRESS (OCTAL)	REGISTER	VECTOR ADDRESS	CHANNEL
176500	RCSR		0
176502	RBUF	300	
176504	XCSR		
176506	XBUF	304	
176510	RCSR		1
176512	RBUF	310	
176514	XCSR		
176516	XBUF	314	
176520	RCSR		2
176522	RBUF	320	
176524	XCSR		
176526	XBUF	324	
177560	RCSR		3
177562	RBUF	60	(Console
177564	XCSR		Device)
177566	XBUF	64	

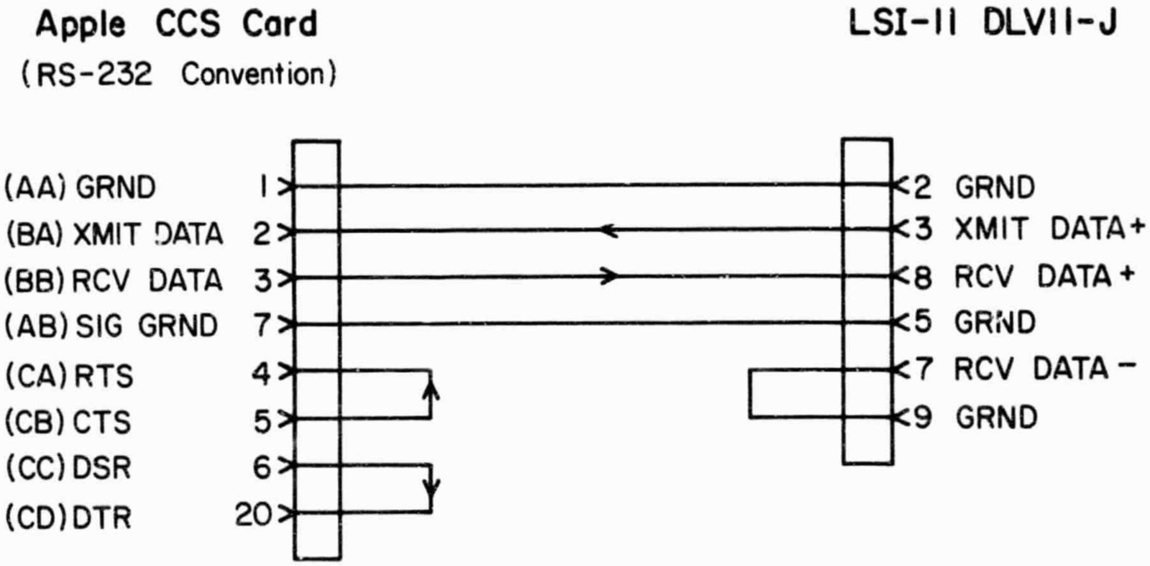


Figure 5.3 Apple CCS card and LSI-11 DLV11-J cable connections.

computers. This section describes the protocol developed for the Apple-LSI-11 serial communication link.

The commands or data sent between the Apple and the LSI-11 are encoded into sequential streams of bytes called "frames" or "packets." The frame format for this application has two parts: the header and the information section. The header part has a beginning-of-frame marker, an operation code or opcode (which determines the use of the frame), an end-of-header marker, and a checksum. The information section has a beginning-of-section marker, the data, an end-of-frame marker, and a checksum. The checksums provide more reliable communications in noisy environments. Figure 5.4 shows the general frame format.

The frame markers consist of two bytes. The first byte is the data-link escape (DLE) which alerts the receiver that the next byte should denote the start of frame (STX), the end of frame (ETX), or the start-of-frame information section (CTX). The values of the marker bytes in hexadecimal are: DLE = $90, STX = $83, ETX = $82, and CTX = $81. To avoid incorrect interpretations of DLE ETX pairs that occur as data, any DLE byte in a data frame is transmitted twice. Upon seeing the DLE DLE pair in a data frame, the receiver saves one of the DLEs and discards the other.

The opcode, following the DLE STX pair in the frame header, identifies the type of frame being transmitted. Five types of frames are used between the Apple and the LSI-11: a commands frame, a data run frame, a data frame, a profile done frame, and an acknowledge frame. The commands and data run frames are only sent from the LSI-11 to the Apple. The commands frame (opcode COM = hexadecimal 32) contains information on the desired laser repetition rate and the number of shots per profile. The data run frame (DRUN = hexadecimal 31) signals the Apple to start collecting a data pro-

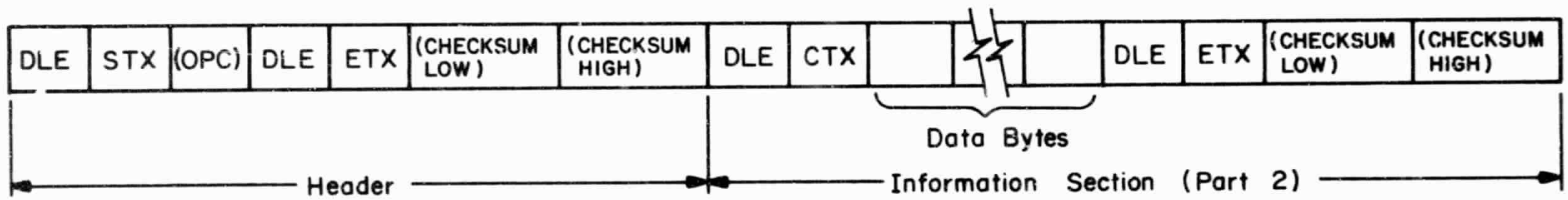


Figure 5.4 General communication frame format.

file. The data and profile done frames are sent one way from the Apple to the LSI-11. The data frames contain the profiles collected by the preprocessing system and the profile done frames (PRDONE = hexadecimal 33) signals the LSI-11 that the profile collection and transmission are completed.

The data frame is unique in that it is of variable length with its maximum length set by a constant (PAKLEN) in the Apple and LSI-11 software. The data frame opcode is also unique in that it is not a constant. This is because of the following two qualities: 1) Due to the method of storing the profile in the Apple RAM the low and high order bytes of the 16-bit profile words are sent in separate data frames; and 2) because of the long length of the high or low byte data frames (2000 bytes each), the data frame was designed to be able to transfer the data with multiple frames as opposed to one frame. The data frame encodes the two qualities given above by using the first hexadecimal digit of the opcode to differentiate the high and low byte frames and the second digit to number the frames (low byte frame = hexadecimal 50 - 5F, high byte frame = hexadecimal E0 - EF). The data frame opcode allows the LSI-11 receiving code to assemble and order the 16-bit profile words correctly upon receipt of the data frames.

After transmitting a command, data run, data, or profile done frame, the sender waits in a timeout loop for the receiver to respond with an acknowledge frame (ACK = hexadecimal 34). If an error is detected in the transmitted frame (for example, a checksum error) no acknowledge is returned, the sender timeout loop expires, and the frame is retransmitted. The sending software attempts to retransmit the frame a number of times (set by a constant, normally 2) before displaying a transmission error message on the terminal or monitor.

The five types of frames are illustrated in Figure 5.5. Only the commands frame and the data frame use the frame information section.

The checksum is the 16-bit summation of all the bytes in the frame (or frame section) except for the first DLE and the final ETX bytes. The header checksum is used to verify the frame opcode and the information checksum is used to detect transmission errors in the data. The header checksum in the commands and data frames is retained to verify that the opcode of the frame is correct before overwriting the old data values in memory with the new data values.

5.3.4 Send routine structure. The sending routines are a set of subroutines in the Apple and LSI-11 data collection software that are responsible for sending the communications frames to the receiving routine of the other computer. The Apple sending subroutines are contained in the Apple Sender program section and are labeled: SNDDAT - send data frame, SNDPRD - send profile done frame, and SNDACK - send acknowledge frame. The LSI-11 sending subroutines are contained in the Macro-11 file SENDER.MAC and are labeled: SNDCOM - send commands frame, SNDDTR - send data run frame, and SNDACK - send acknowledge frame.

Apple subroutines SNDDAT and SNDPRD along with LSI-11 subroutines SNDCOM and SNDDTR not only output the frame bytes to the communications serial port, but also wait after transmission in a timeout loop for a returning acknowledge frame. If the timeout loop is completed before the acknowledge is received, the frame is retransmitted. An error index is decremented each time a retransmission is necessary, and an error message is displayed on the sender's console after two retransmissions fail (the total number of transmission attempts is set at 3 by the constant ERRCNT, although ERRCNT can easily be changed). After a frame transmission failure

DLE	STX	COM	DLE	ETX	(CHECKSUM LOW)	(CHECKSUM HIGH)	DLE	CTX	REPNUM	SHOTS/PRF LOW BYTE	SHOTS/PRF HIGH BYTE	(CHECKSUM LOW)	(CHECKSUM HIGH)

a) Commands frame

DLE	STX	DRUN	DLE	ETX	(CHECKSUM LOW)	(CHECKSUM HIGH)

b) Data run frame

DLE	STX	(DATA OPC)	DLE	ETX	(CHECKSUM LOW)	(CHECKSUM HIGH)	DLE	CTX			(CHECKSUM LOW)	(CHECKSUM HIGH)

Data Bytes

c) Data frame

DLE	STX	PR-DONE	DLE	ETX	(CHECKSUM LOW)	(CHECKSUM HIGH)

d) Profile done frame

DLE	STX	ACK	DLE	ETX	(CHECKSUM LOW)	(CHECKSUM HIGH)

e) Acknowledge frame

Figure 5.5 Formats for different types of communication frames.

(including the retransmission attempts), the operator has a choice of attempting the frame transmission again or exiting the sending routine. The choice is prompted by the question "Try again?" which is displayed on the sending computer console after the transmission error message.

The flowchart of the LSI-11 subroutine SNDCOM in Figure 5.6 illustrates the general structure of all the sending subroutines. First, each routine loads its respective opcode into the transmit opcode variable (OPCDE). Next, the retransmission error count (ERRORS) and the acknowledge flag (ACKFLG) are initialized. Finally, the frame bytes are sent to the communications serial port and the routine begins to execute the timeout wait loop. If an acknowledge frame is returned to the sending computer, during the wait loop, the receiving routine sets ACKFLG which drops the sending routine out of the timeout loop.

Although the general program structure of each frame sending routine is similar, there are some structure differences due to the nature of the frames. For example, the SNDACK subroutines do not incorporate the timeout loop as they have no use for it. Also, the final task of the SNDCOM subroutine is to call SNDDTR, as a commands frame will always be followed by a data run frame.

Because of the multiple low byte and high byte data frames discussed in Section 5.3.3 on Protocol, the Apple subroutine SNDDAT has some complications added to the general sending subroutine structure. A flowchart for SNDDAT is shown in Figure 5.7. SNDDAT actually uses the subroutine DATOUT to output the data frames. DATOUT is called by SNDDAT, once to send the low byte data frames and once to send the high byte data frames. Three variables must be loaded before calling DATOUT: the base data frame opcode (hexadecimal 50 or E0) is loaded into DATOPC, ADDRES holds the starting

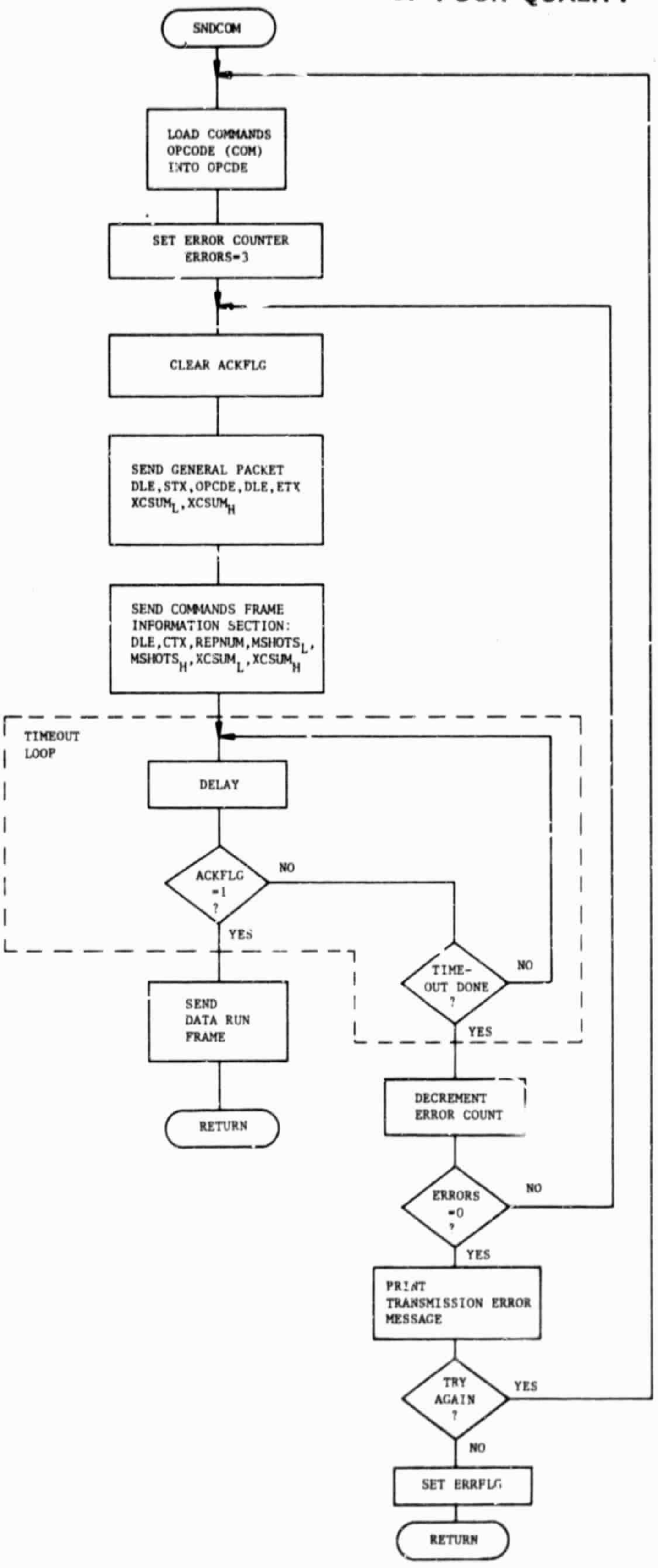


Figure 5.6 Flowchart of LSI-11 subroutine SNDCOM.

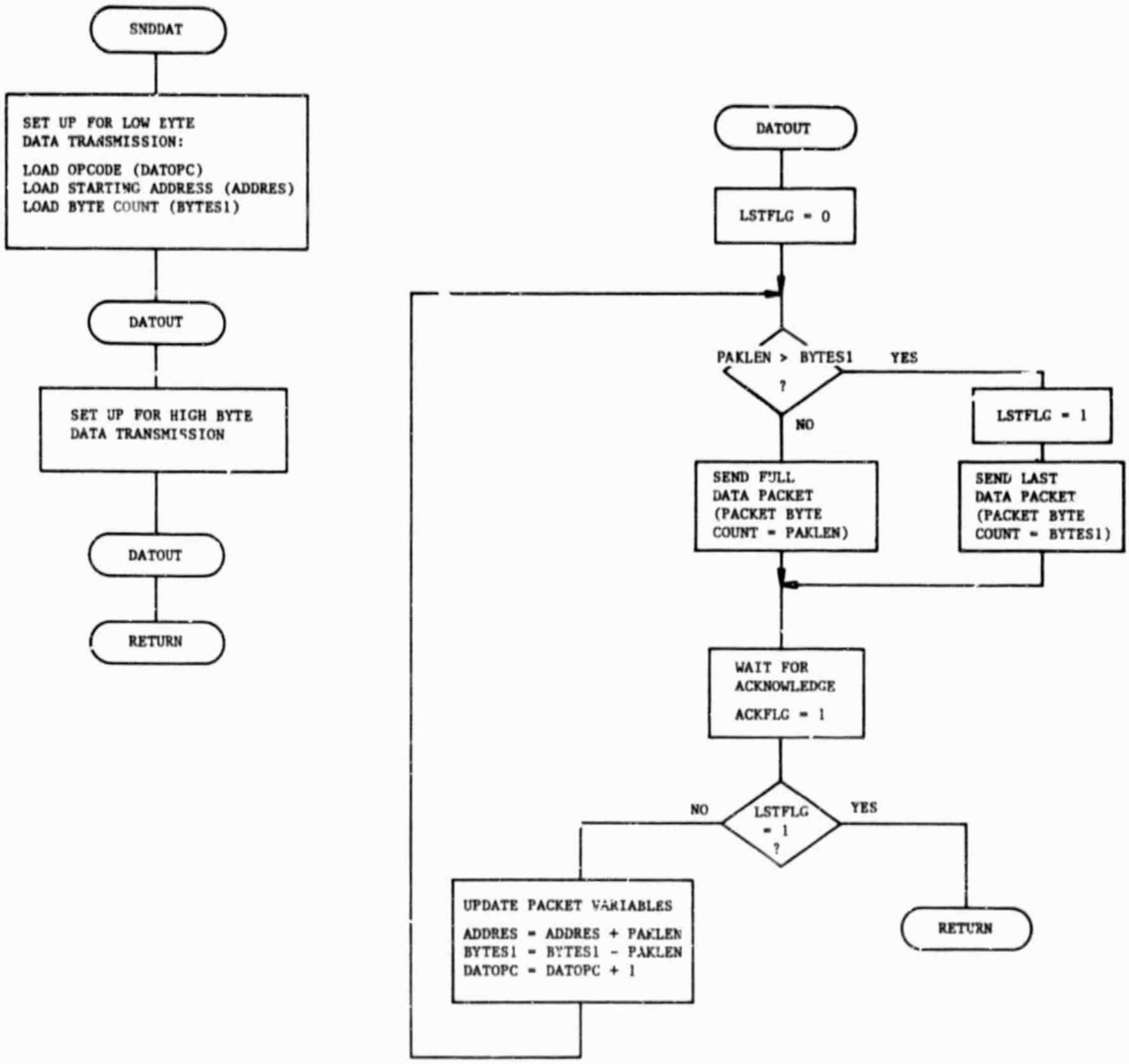


Figure 5.7 Flowchart of Apple subroutine SNDDAT.

location of the block of bytes to be transferred, and BYTES1 contains the transfer byte count. DATOUT uses the variable values to break the blocks of data into multiple data frames. The constant PAKLEN sets the maximum number of data bytes in one frame. The DATOUT routine was designed so that changing the maximum packet length is simply a matter of changing PAKLEN and recompiling the Apple program. Section 5.4 on Data Collection Software Options contains a more detailed discussion on changing the maximum data frame length.

In the data frames, data bytes that happen to have the same value as the DLE marker byte are doubled to avoid a false end-of-frame marker. Upon receipt, the LSI-11 receiving routine saves one of the DLEs as data and discards the other.

5.3.5 Receive routine structure. Figures 5.8 and 5.9 show the receiving routine flowcharts for the Apple and LSI-11, respectively. These routines receive and decode the frames sent by the sending routine of the other computer. Both Apple and LSI-11 routines are interrupt service routines with differences between the routines arising from the receiving of different types of frames. The Apple routine is contained in the Apple Receiver program section and the LSI-11 routine is contained in the Macro-11 file RCVER.MAC.

Each incoming byte on the communication serial port (of either computer) causes an interrupt which results in the program control jumping to the receiving routine. The incoming byte essentially enters the receiving routine at one of the GET BYTE blocks shown in the flowcharts. (The GET BYTE blocks actually represent the subroutine GTBYTE in the receiving code. When called, GTBYTE saves the return address in the variable STATE and executes a return from interrupt. The interrupt from the next incoming byte

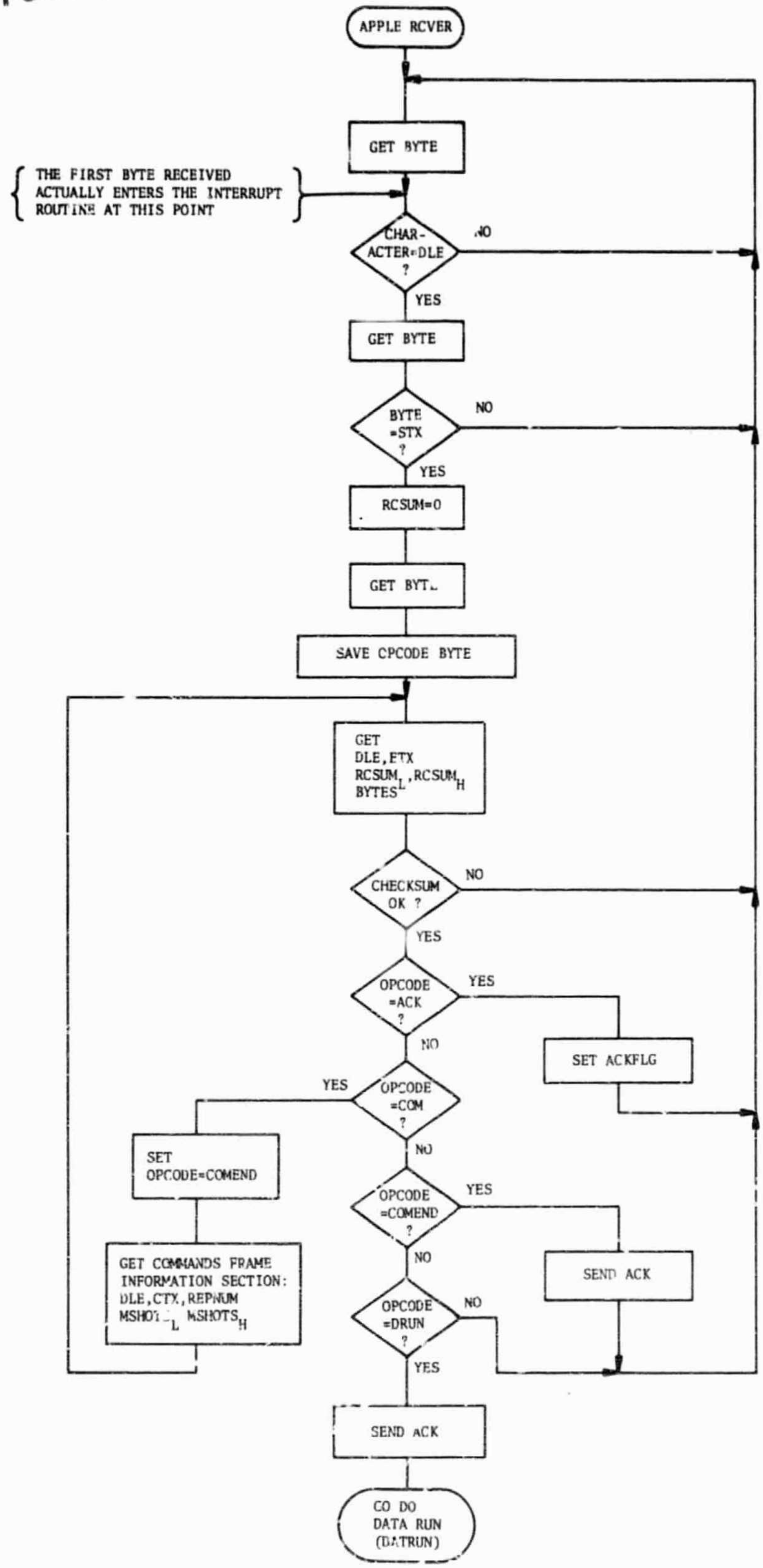


Figure 5.8 Flowchart of Apple receiving routine.

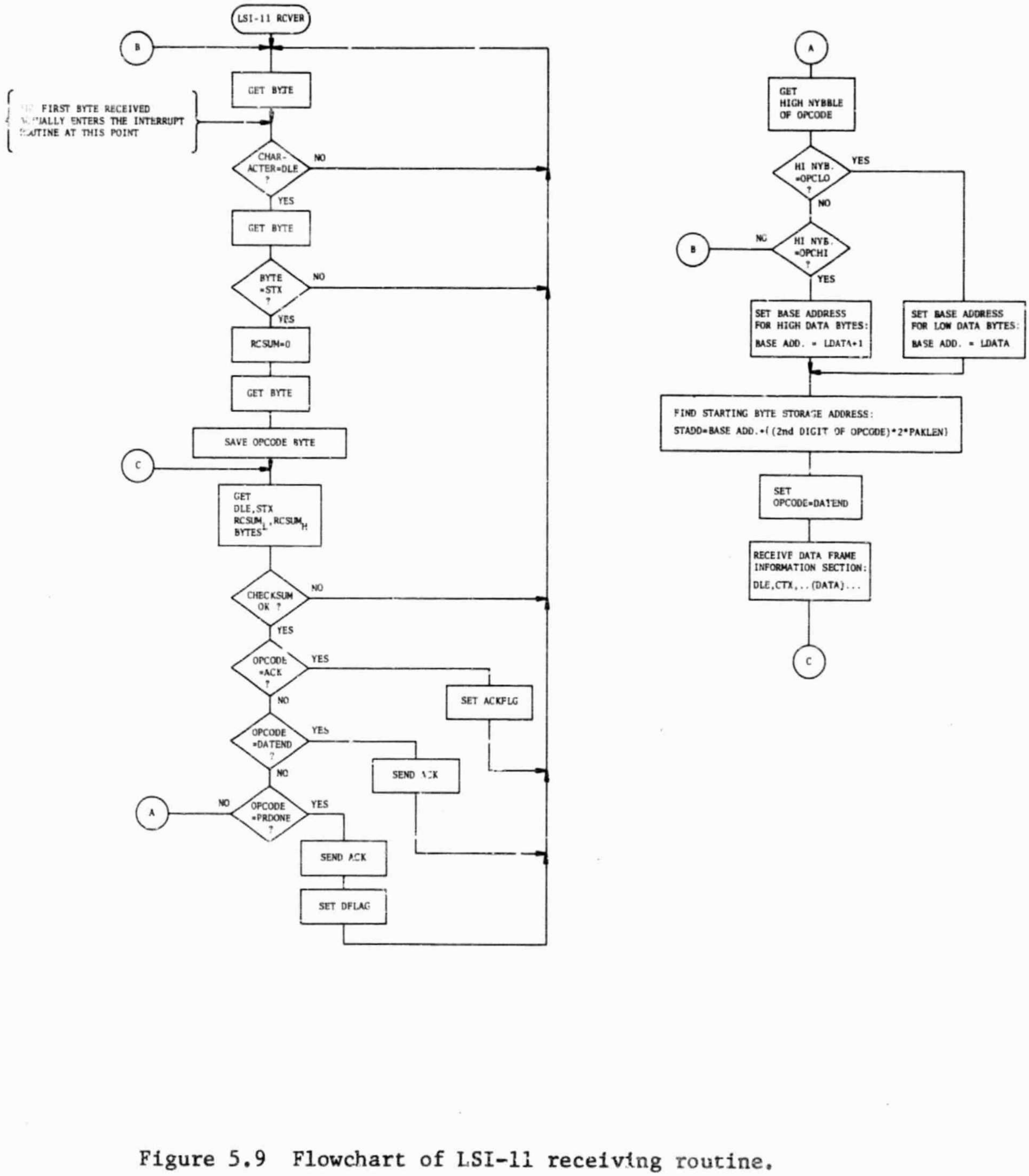


Figure 5.9 Flowchart of LSI-11 receiving routine.

results in the reentering of the receiving routine at the address stored in STATE and the incoming byte is processed by the correct portion of the receiving code. However, it is conceptually easier to think of the GET BYTE blocks as simply a wait followed by an incoming byte.)

The initial portion of the receiving code checks for the DLE STX beginning-of-frame marker. If the bytes are not DLE STX, control returns to the beginning of the receiving code.

After receiving the DLE STX pair, the next incoming byte is assumed to be the frame opcode and is saved for interpretation after the header checksum is received.

Next, the DLE ETX pair and the two bytes of the header checksum are received. If the received checksum equals the calculated checksum, the routine interprets the frame opcode. If not, control returns to the beginning of the receiving code.

In both the Apple and LSI-11 routines an ACK opcode causes the acknowledge flag (ACKFLG) to be set. In the Apple routine the COM opcode implies that the commands frame information section will be transmitted next. The DRUN opcode implies a data run is being requested.

In the LSI-11 routine the PRDONE opcode indicates a data profile has been transmitted successfully and the data flag DFLAG is set. The data frame opcode is the last to be checked for by the LSI-11 routine. The first hexadecimal digit of the data frame opcode designates the frame as high or low byte data, and the second hexadecimal digit is used to place the frame in the correct section of the array LDATA. The low order byte data are stored in the even byte address locations within LDATA and the high order byte data are stored in the odd byte address locations. This procedure results in the separately transmitted high and low bytes of the data profile

being paired as 16-bit words in the array LDATA.

The opcodes COMEND in the Apple receiving code and DATEND in the LSI-11 code are dummy opcodes which are loaded into the opcode variable while the information section of a commands frame or a data frame is being received. The dummy opcodes are essentially flags which allow the checksum testing code (before the opcode identification) to be reused for the end of the information frame section.

After a frame is successfully received and the appropriate action is taken, control returns to the beginning of the receiving code so that the next incoming frame may be interpreted correctly.

5.4 Data Collection Software Options

This section describes the real time interactive options available in the collection software that are not obvious to an inexperienced operator. Also mentioned in this section are some important program changes which allow the collection software to be adapted for use in various experiment situations.

For the most part, all of the real time interaction between the main computer/preprocessing system and the lidar operator is accomplished through the LSI-11 console terminal. Occasionally, the Apple keyboard must be accessed to allow the preprocessing system to continue after a laser triggering error. With the collection software running, the LSI-11 console terminal should initially display the main collection menu (see Section 5.2.2). Selecting one of the menu options results in a jump to a corresponding subroutine, and in general, each option subroutine halts at some point to prompt the operator for an input of some type. At this point, in menu options 1 through 5, typing a carriage return will result in a return to the main menu. Menu option 6, the profile data examine routine (EXMPRF),

initially asks for a set and profile number. Inputting the value zero (0) for either number will result in a return to the main menu. Menu option 7, the hexadecimal dump of the data array LDATA, supplies no prompts and the array values are simply displayed on the terminal. After the display is completed a return to the main menu is automatically executed.

The three data collection options in the main menu (options 3, 4, and 5; routines LAALN, ALRTN, and DATRUN) all execute a waiting loop while the preprocessing system is collecting data. Normally, the loop is exited when the profile is successfully received by the LSI-11. However, the operator can force the routine to exit the waiting loop at any time by typing "s" and a carriage return. This option allows routine execution to be returned to the main collection menu when problems occur with the laser (or any other system hardware) while a data profile is being collected. This option is created through the use of the Fortran function ITTINR.

The preprocessing system requires the use of two peripheral cards in the Apple computer peripheral slots: A CCS serial communications card and the preprocessor DMA card. The Apple collection software presented in Appendix III.1 requires the CCS card to be mounted in slot 2 and the DMA card to be mounted in slot 4. However, these slot assignments can be changed by first altering the values of the constants CSR, DMAREG, and SLPIO in the program and then recompiling the program. CSR is the location of the CCS card status register, DMAREG is the beginning location for the DMA card programmable registers, and SLPIO is the beginning location for the DMA card Control Signals (see Appendix III.1).

Two floppy disk drives are required by the LSI-11 collection software to collect data in an efficient manner. One drive contains the system floppy disk and the other drive contains the data floppy disk. The system

disk is generally assigned as the drive on which the computer is booted. The data drive is assigned in the main program file FZZ.FOR in the first four locations of the array variable FNAME. Presently the data disk is assigned as DYO:.

As mentioned throughout Section 5.3 on Data Collection Communication Routines, the data frames sent from the Apple to the LSI-11 are of variable length with the maximum data byte count set by the constant PAKLEN. Changing the maximum data byte count is done by first setting the PAKLEN constant in both the Apple Sender program section and the LSI-11 RCVER section to the desired value and then recompiling the programs. Because of the error checking feature (checksum) of the frame communications technique, in a noisy environment many short data frames may provide more efficient transmission than a fewer number of long data frames. For this reason, a simple method of changing the maximum data byte count in a data frame was provided.

5.5 Data Conversion Software

During data collection, the collection software permanently stores sets of profiles on a floppy disk in unformatted direct access files. The data values in these files are represented in a binary format. After the collection is completed the data are transferred to the University of Illinois CYBER computer for further processing. However, the binary data files must be converted to files with an ASCII format before the transfer can occur. This is due to hardware restrictions in the LSI-11-CYBER link used to transfer the data. The routine CONVRT.SAV is used to accomplish the binary-to-ASCII file conversion.

CONVRT initially requests the name of the device containing the binary files and the name of the device on which the converted files will be

stored. Typical responses might be DY0: and DM1:. Next, a set number is requested and also the total number of profiles in the set must be entered. CONVRT also requests the input of four values that are not recorded in the binary data files. These values are the ground speed (kts), altitude (ft), latitude (deg.-min.), and longitude (deg.-min.) at the time the profile was collected. These are values that were recorded manually during the airborne experiment discussed in Chapter 6; and CONVRT inserts them into the ASCII data files.

The binary-to-ASCII conversion is accomplished with the use of the Fortran functions ENCODE and DECODE. The binary files designated by the name SETxxx.DAT are converted and saved in new files designated by the name SETxxx.ASC, where xxx is the set number. The listing of CONVRT in Appendix III.14 shows the format of the ASCII data files.

6. PRELIMINARY RESULTS OF AN AIRBORNE EXPERIMENT

6.1 Introduction

In March 1983, the University of Illinois Aeronomy Laboratory (Lidar Group) conducted an airborne sodium lidar experiment aboard a National Aeronautics and Space Administration (NASA) aircraft. The primary goal of the experiment was to determine the feasibility of obtaining mesospheric sodium density measurements with an airborne lidar system. In reference to this report, the initial testing of the new sodium lidar preprocessing system with the complete lidar system was conducted during this airborne experiment.

Initial sodium lidar measurements by the University of Illinois Lidar Group were made from ground-based stations [Richter and Sechrist, 1978; Shelton and Gardner, 1981]. Generally, these experiments provided information on the temporal structure of the mesospheric sodium layer as the layer drifted above the test site. In addition, the use of a steerable receiving telescope at NASA Goddard Space Flight Center provided limited observations of the horizontal structure of the layer. An airborne lidar system holds two distinct advantages over these ground-based systems. First, attenuation of the transmitted laser pulse due to low-altitude cloud cover and haze can be alleviated by flying above the obstructions. Second, the aircraft allows observations to be recorded over a long horizontal base line, an essential requirement for good horizontal structure measurements of the layer. This particular airborne experiment was designed as a forerunner to more extensive airborne sodium lidar observations.

6.2 Airborne Sodium Lidar System

The sodium lidar system was flown aboard the NASA Lockheed Electra

L-188 turboprop aircraft (Figure 6.1). The aircraft is stationed at NASA Wallops Flight Center, Wallops Island, Virginia. The University of Illinois lidar equipment was used in conjunction with the NASA Electra Lidar Facility. This Lidar Facility consists of three standard optical table tops and a 16-inch, f/2.5 primary, receiving telescope all mounted on a table support structure.

The telescope is mounted near the center of the support table in an upward pointing position. Two of the optical table tops are positioned on top of the support table on either side of the telescope. The third optical table top is mounted in the support structure underneath the larger upper table top. The support structure is bolted to the floor of the aircraft with the telescope positioned beneath a quartz window in the roof of the plane's cabin.

The dye laser and transmitting optics for the lidar system were fastened to the larger upper table top of the Lidar Facility. The laser beam was steered through the quartz window, located directly over the telescope, with dielectric-coated optics. The receiving components, including the preprocessing system, were fastened to the smaller upper table top of the Lidar Facility. Power supplies and laser tuning equipment were mounted on the lower table top. Figure 6.2 shows the equipment configuration on the receiving side of the Lidar Facility. Figure 6.3 is a photograph of the equipment from the transmitting side of the Facility. The laser high-voltage power supply and chiller unit in Figure 6.3 were bolted to the floor of the aircraft. Also shown in Figure 6.3 are the nitrogen gas bottle, which provided nitrogen for purging the laser dye of oxygen, and the line printer used by the LSI-11 main computer.

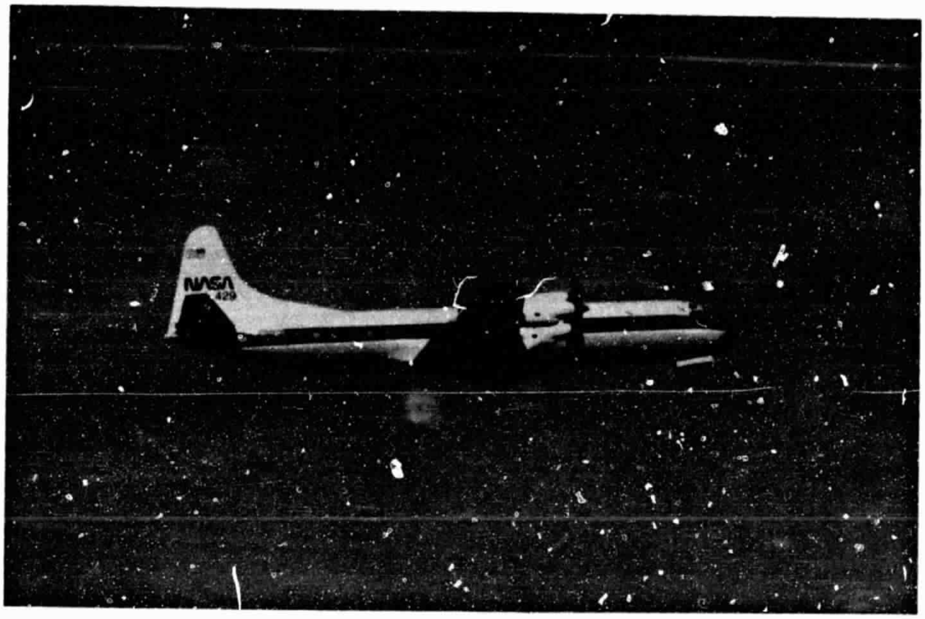


Figure 6.1 Photograph of the NASA Electra aircraft.

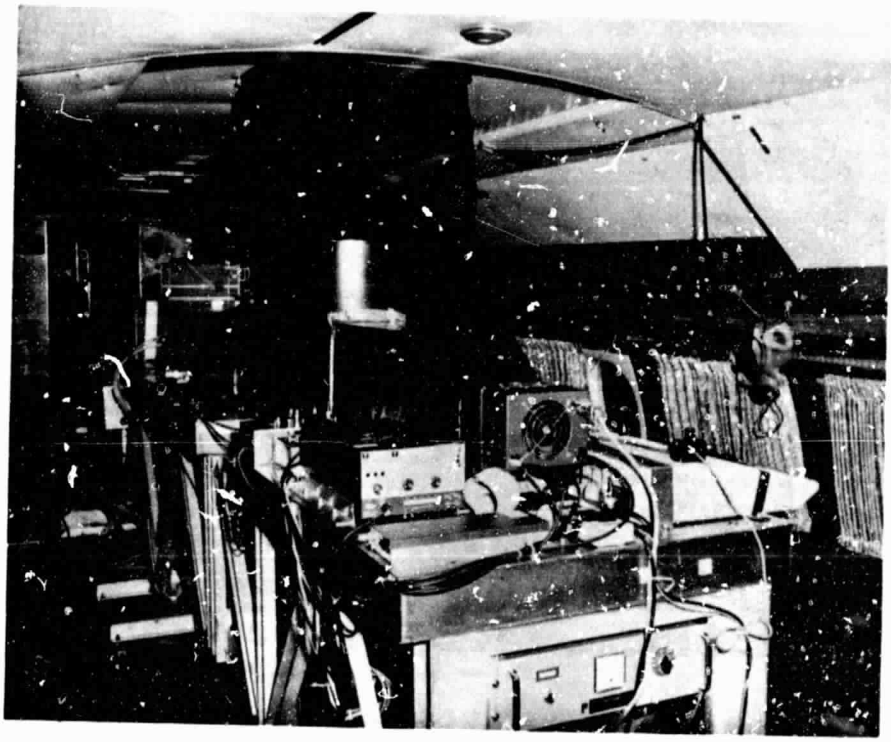


Figure 6.2 Photograph of the lidar receiving system equipment aboard the NASA Electra. On top of the table in the foreground from left to right are the amplifier-discriminator, PMT housing, and the preprocessor Apple microcomputer.

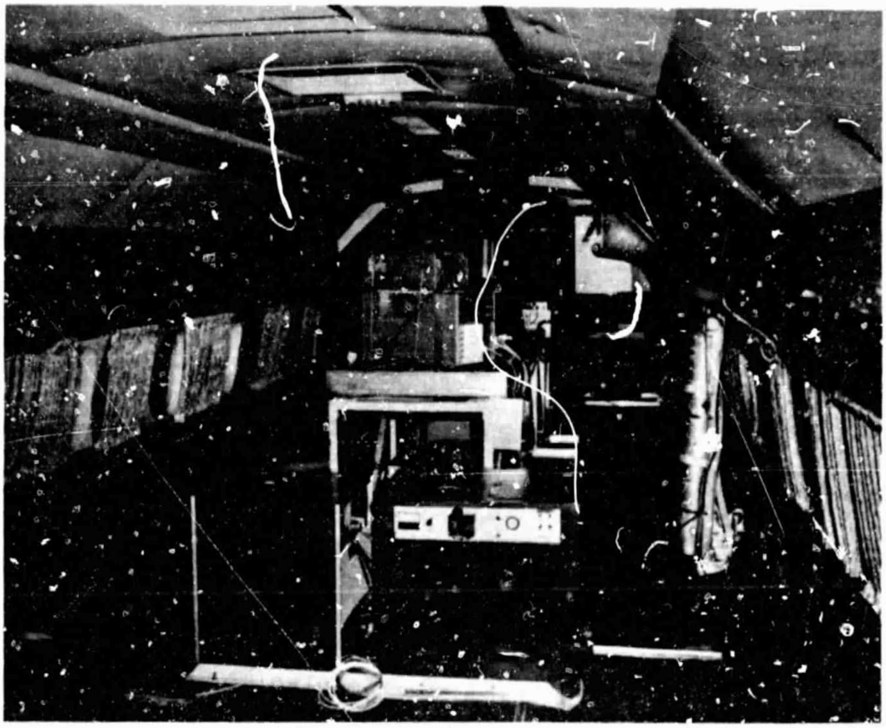


Figure 6.3 Photograph of the lidar transmitting system equipment aboard the NASA Electra. In the foreground on the floor are the laser high-voltage power supply and chiller unit. On the table are the laser tuning monitor oscilloscopes. The laser head is located on the table behind the oscilloscopes.

Figure 6.4 shows the computer rack. This rack was positioned across the aisle from the line printer. Mounted in the rack were the LSI-11 computer, disk drive, terminal, monitor, and the preprocessing system Apple monitor.

6.3 Results

The airborne lidar test was conducted on the night of March 30, 1983 beginning at approximately 2130 EST. The flight originated at Wallops Flight Center (38 °N, 74 °W), reached a turn-around point near Albany, NY (42 °N, 73 °W), and terminated at Wallops at approximately 2330 EST. Although data collection began during the ascent, scattering of the laser beam by high cirrus clouds prevented collection of good sodium data until the aircraft reached an altitude above 25,000 feet. A similar collection problem occurred during the descent. Also, occasional cirrus above 30,000 feet attenuated the received sodium signal photons at various points in the experiment.

Plots of the spatial variations in estimates of the sodium density are shown in Figure 6.5. Figure 6.5(a) shows sodium density profiles collected on the outbound leg of the flight and Figure 6.5(b) shows profiles collected on the return leg. Each profile required 2,000 laser shots. The peak sodium concentration is seen to be located above 90 km which is consistent with previous measurements obtained during the month of March with the ground-based systems. The distribution of the sodium density around the peak is also consistent with previous ground-based observations. The profiles seem to have some related structural features such as the descending local peaks beneath the principal peaks in the three profiles on the right side of Figure 6.5(b). Another interesting feature, most notable in Figure 6.5(a), is a possible secondary layer appearing above 100 km.

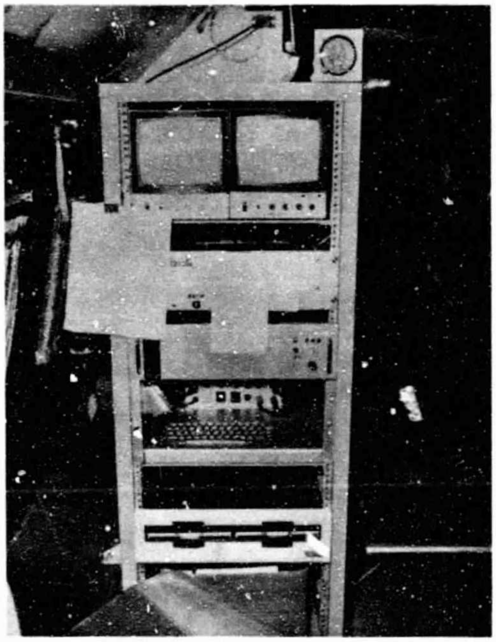


Figure 6.4 Photograph of the computer rack aboard the NASA Electra. Mounted in the rack from top to bottom are the LSI-11 and Apple monitors, the LSI-11 power supply and computer backplane, the LSI-11 keyboard, and the LSI-11 floppy disk drives.

C-2

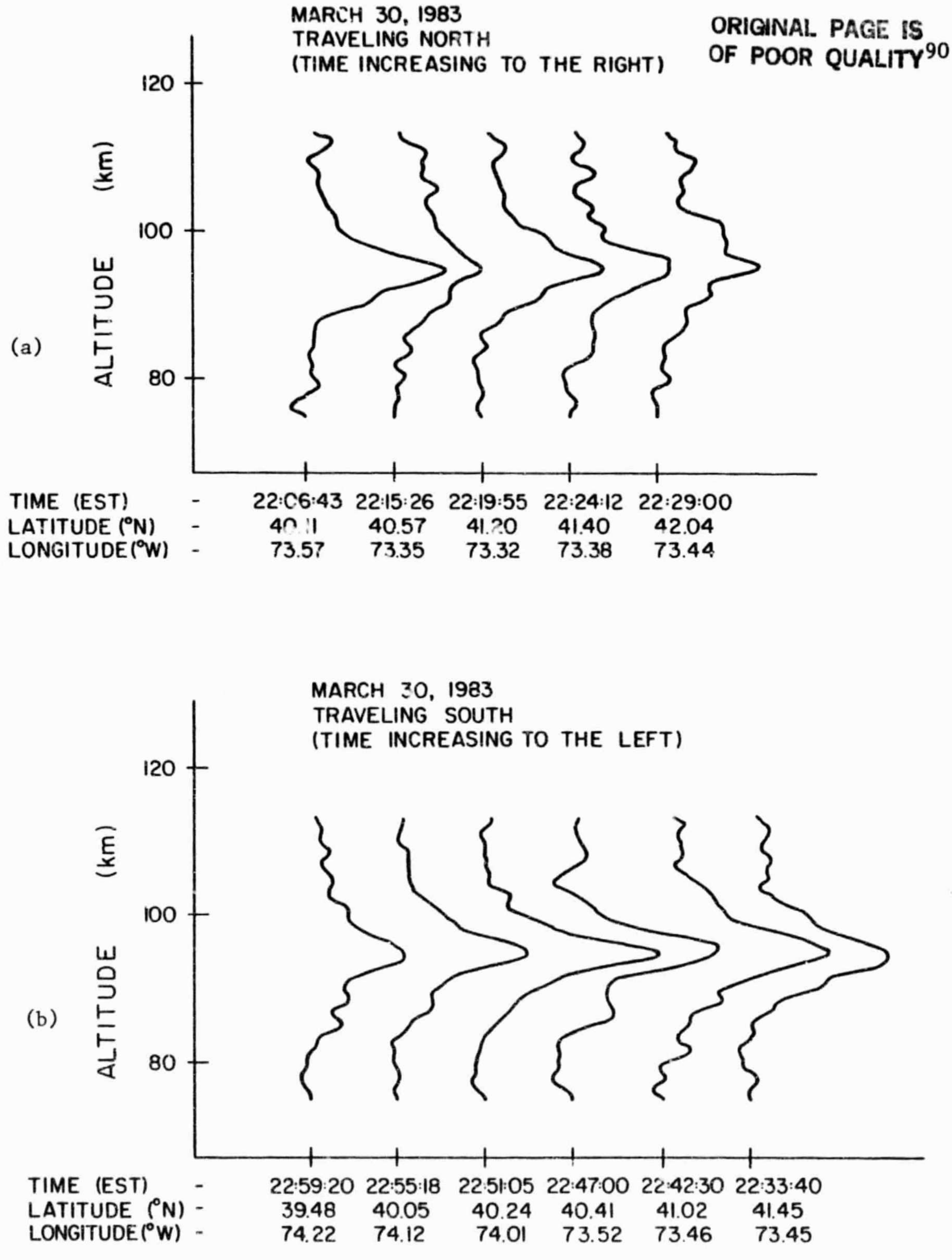


Figure 6.5 Time and location history of the estimated altitude profiles of sodium density observed on (a) the outbound leg and (b) the return leg of the airborne experiment conducted on March 30, 1983. A Hamming window lowpass filter with a cutoff of .35 km^{-1} was used to spatially filter the profiles.

7. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The preliminary results of the airborne sodium lidar experiment presented in Chapter 6 indicate that the preprocessing system is functioning as designed. The sodium layer profiles collected during the experiment contain features that are similar to those typically observed by sodium lidar systems. Noise in the data resulting from cloud cover and other factors makes it difficult to evaluate the performance of the preprocessing system in an absolute manner. However, no obvious contamination of the data directly attributable to the preprocessing system was noticed.

Desirable future additions to the preprocessing and main computer systems would include the capability of further real-time processing of the data during collection. This might involve digitally filtering the data and displaying the filtered profiles on a graphics terminal. This type of immediate feedback would help in maintaining the lidar system at an optimal operation level. For example, drifting of the laser tuning would be clearly noticeable in the displayed profiles. Also, the displayed profiles would indicate the quality of the data and any interesting features of the profiles.

Because of the interrupt structure of the preprocessing system software, both the Apple and LSI-11 computers may be employed to run background routines in addition to the data collection routines. This provides the option of controlling any of the lidar system equipment with a computer. Examples would be computer-directed laser tuning and computer-controlled alignment of the transmitted and received beams.

APPENDIX I CARD AND CABLE PINOUTS

I.1 Apple Peripheral Card Connector Pinout

PIN	NAME	FUNCTION
1	$\overline{\text{I/O SELECT}}$	MEMORY MAPPED SELECT LINE
2	A0	
3	A1	
4	A2	
5	A3	
6	A4	
7	A5	
8	A6	
9	A7	ADDRESS BUS
10	A8	
11	A9	
12	A10	
13	A11	
14	A12	
15	A13	
16	A14	
17	A15	
18	R/$\overline{\text{W}}$	READ/WRITE
19	N.C.	
20	$\overline{\text{I/O STROBE}}$	MEMORY MAPPED STROBE LINE
21	RDY	6502 'READY' LINE
22	$\overline{\text{DMA}}$	DIRECT MEMORY ACCESS CONTROL LINE
23	INT OUT	INTERRUPT DAISY CHAIN OUTPUT
24	DMA OUT	DMA DAISY CHAIN OUTPUT
25	+5V	+5 VOLTS
26	GND	LOGICAL GROUND
27	DMA IN	DMA DAISY CHAIN INPUT
28	INT IN	INTERRUPT DAISY CHAIN INPUT
29	$\overline{\text{NMI}}$	NON MASKABLE INTERRUPT REQUEST
30	$\overline{\text{IRQ}}$	INTERRUPT REQUEST
31	$\overline{\text{RES}}$	RESET LINE
32	$\overline{\text{INH}}$	ROM INHIBIT LINE
33	-12V	-12 VOLTS
34	-5V	-5 VOLTS
35	N.C.	
36	7M	7 MHZ CLOCK
37	Q3	2 MHZ (ASYMMETRIC) CLOCK
38	Φ1	PHASE 1 CLOCK
39	USER1	INTERNAL I/O ADDRESS DISABLE
40	Φ0	PHASE 0 CLOCK (ALSO Φ2)
41	$\overline{\text{DEVICE SELECT}}$	MEMORY MAPPED SELECT LINE
42	D7	
43	D6	
44	D5	
45	D4	DATA BUS
46	D3	
47	D2	
48	D1	
49	D0	
50	+12V	+12 VOLTS

I.2 Apple DMA Card Ribbon Connector Pinout

PIN	NAME	FUNCTION
1	GND	
2		
3		
4		
5		
6		LOGIC GROUND
7		
8		
9		
10		
11	GND	
12	$\overline{Y3}$	CONTROL LINE $\overline{Y3}$
13	$\overline{Y1}$	CONTROL LINE $\overline{Y1}$
14	$\overline{RES}$	RESET LINE
15	$\overline{TxRQ}$	DMA TRANSFER REQUEST
16	N.C.	
17	N.C.	
18	$\overline{DEND}$	DMA END SIGNAL
19	$\overline{TxSTB}$	DMA TRANSFER STROBE
20	$\overline{TxAKA}$	DMA TRANSFER ACKNOWLEDGE
21	$\overline{DGRNT}$	DMA BUS GRANT
22	$\overline{Y2}$	CONTROL LINE $\overline{Y2}$
23	$\overline{Y4}$	CONTROL LINE $\overline{Y4}$
24	$\overline{Q3}$	INVERTED APPLE Q3 CLOCK
25	$\Phi 0$	APPLE $\Phi 0$ CLOCK
26	$\Phi 1$	APPLE $\Phi 1$ CLOCK
27	D0	
28	D1	
29	D2	
30	D3	DATA LINES
31	D4	
32	D5	
33	D6	
34	D7	

I.3 SLIPP Unit External Ribbon Connector Pinout

PIN	NAME	FUNCTION
1	$\overline{\mathrm{DEND}}$	DMA END SIGNAL
2	$\overline{\mathrm{TxSTB}}$	DMA TRANSFER STROBE
3	$\overline{\mathrm{TxAKA}}$	DMA TRANSFER ACKNOWLEDGE
4	$\overline{\mathrm{DGRNT}}$	DMA BUS GRANT
5	$\overline{\mathrm{Y2}}$	CONTROL LINE $\overline{\mathrm{Y2}}$
6	$\overline{\mathrm{Y4}}$	CONTROL LINE $\overline{\mathrm{Y4}}$
7	$\overline{\mathrm{Q3}}$	INVERTED APPLE Q3 CLOCK
8	$\Phi 0$	APPLE $\Phi 0$ CLOCK
9	$\Phi 1$	APPLE $\Phi 1$ CLOCK
10	D0	
11	D1	
12	D2	
13	D3	DATA LINES
14	D4	
15	D5	
16	D6	
17	D7	
18	GND	
19		
20		
21		
22		
23		LOGIC GROUND
24		
25		
26		
27		
28	GND	
29	$\overline{\mathrm{Y3}}$	CONTROL LINE $\overline{\mathrm{Y3}}$
30	$\overline{\mathrm{Y1}}$	CONTROL LINE $\overline{\mathrm{Y1}}$
31	$\overline{\mathrm{RES}}$	RESET LINE
32	$\overline{\mathrm{TxRQ}}$	DMA TRANSFER REQUEST
33	N.C.	
34	N.C.	

I.4 SLIPP Unit Internal Card Edge Connector Pinout

PIN	NAME	FUNCTION
A	+5V	+5 VOLTS
B	D7	
C	D6	
D	D5	
E	D4	DATA LINES
F	D3	
H	D2	
J	D1	
K	D0	
L	$\Phi 1$	APPLE $\Phi 1$ CLOCK
M	$\Phi 0$	APPLE $\Phi 0$ CLOCK
N	$\overline{Q3}$	INVERTED APPLE Q3 CLOCK
P	$\overline{Y4}$	CONTROL LINE $\overline{Y4}$
R	$\overline{Y2}$	CONTROL LINE $\overline{Y2}$
S	$\overline{DGRNT}$	DMA BUS GRANT
T	$\overline{TxAKA}$	DMA TRANSFER ACKNOWLEDGE
U	$\overline{TxSTB}$	DMA TRANSFER STROBE
V	$\overline{DEND}$	DMA END SIGNAL
W	N.C.	
X	N.C.	
Y	N.C.	
Z	GND	LOGIC GROUND
1	-5V	-5 VOLTS
2	GND	
3		
4		
5		
6		
7		LOGIC GROUND
8		
9		
10		
11		
12	GND	
13	$\overline{Y3}$	CONTROL LINE $\overline{Y3}$
14	$\overline{Y1}$	CONTROL LINE $\overline{Y1}$
15	$\overline{RES}$	RESET LINE
16	$\overline{TxRQ}$	DMA TRANSFER REQUEST
17	N.C.	
18	N.C.	
19	AUX OUT	AUXILIARY OUTPUT
20	TRIG	LASER TRIGGER OUPUT
21	LCP	LASER COMMAND PULSE INPUT
22	NIM	FAST NIM DISCRIMINATOR INPUT

APPENDIX II CARD COMPONENT DIAGRAMS

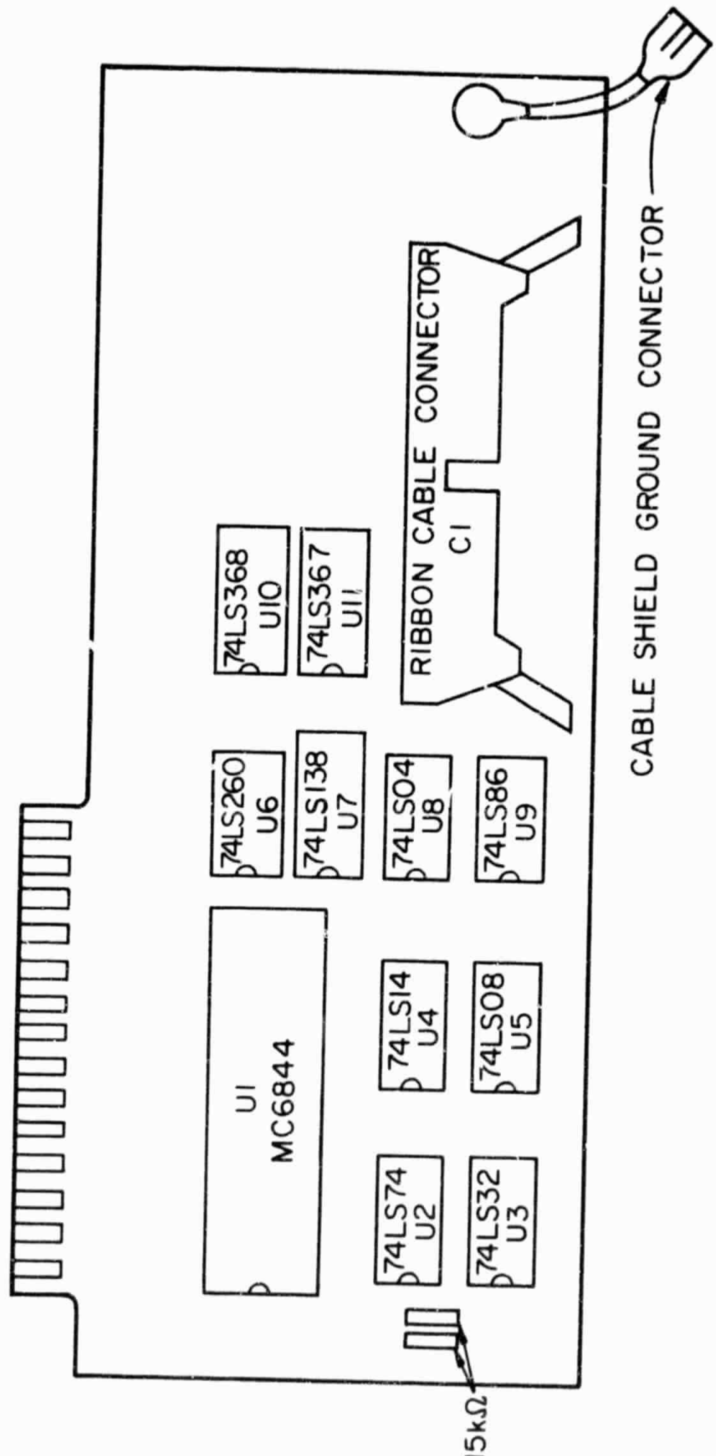


Figure II.1 Apple DMA card component diagram.

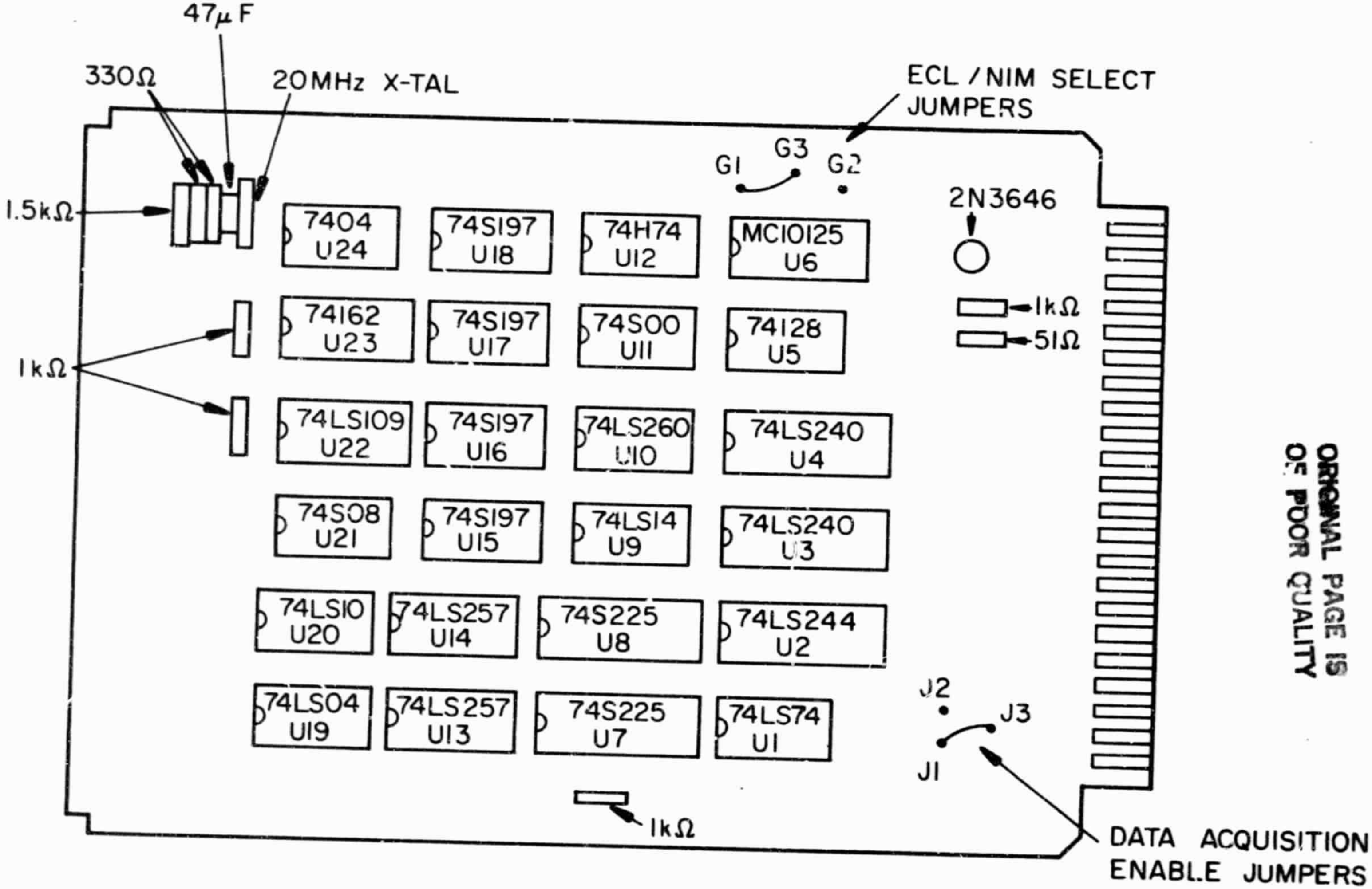


Figure II.2 SLIPP unit circuit component diagram.

APPENDIX III SOFTWARE LISTINGS

III.1 SLPAPP

```
SOURCE FILE: SLPAPP
 ---- NEXT OBJECT FILE NAME IS SLPAPP.OBJ
0C28:              ORG  $0C28
0C28:        ********************************
0C28:        *
0C28:        *          APPLE
0C28:        *       SLIPP SOFTWARE
0C28:        *          D.VOELZ
0C28:        *       FEB. 20, 1983
0C28:        *
0C28:        ********************************
0C28:        *
0C28:        *  I/O  LOCATIONS
0C28:        *
C0A0:        CSR      EQU  $C0A0      ;SERIAL CARD IN SLOT 2
C0A1:        XRDR     EQU  CSR+1
0C28:        *
C400:        DMAREG   EQU  $C400      ;DMA BOARD IN SLOT 4
C0C0:        SLPIO    EQU  $C0C0
C0C1:        TRIG     EQU  SLPIO+1
C0C4:        SLPRST   EQU  SLPIO+4
0C28:        *
0C28:        *  GENERAL PARAMETERS
0C28:        *
0003:        ERRCNT   EQU  3          ;ERROR COUNT
0032:        DEL1     EQU  50         ;DELAY PAR. 1
0031:        DRUN     EQU  $31        ;OPCODES -DATA RUN
0032:        COM      EQU  $32        ;        -COMMANDS
0033:        PRDONE   EQU  $33        ;        -PROFILE DONE
0034:        ACK      EQU  $34        ;        -ACKNOWLEDGE
0045:        COMEND   EQU  $45        ;        -COMMANDS DONE
0081:        CTX      EQU  $81        ; 'CTX' CHAR
0082:        ETX      EQU  $82        ; 'ETX' CHAR
0083:        STX      EQU  $83        ; 'STX' CHAR
0090:        DLE      EQU  $90        ; 'DLE' CHAR
03FE:        INTV     EQU  $03FE      ;INTERRUPT VECTOR
FCA8:        WAIT     EQU  $FCA8      ;DELAY ROUTINE
FF3F:        IOREST   EQU  $FF3F      ;RESTORE REGISTERS
FF4A:        IOSAVE   EQU  $FF4A      ;SAVE REGISTERS
0C28:        *
0C28:        *  DATA PACKET PARAMETERS
0C28:        *
0050:        OPCLO    EQU  $50        ;LO BYTE DATA OPCODE
00E0:        OPCHI    EQU  $E0        ;HI BYTE DATA OPCODE
6000:        BUFADD   EQU  $6000      ;INPUT BUFFER MEMORY
9000:        STADDL   EQU  $9000      ;LO BYTE MAINFRAME MEMORY
9800:        STADDH   EQU  STADDL+$800 ;HI BYTE MAINFRAME MEMORY
```

```
07D0:    PAKLEN   EQU   2000       ;PACKET LENGTH (MAX=32767)
07D0:    BYTCNT   EQU   2000       ;BYTE COUNT
0C28:    *
0C28:    *  MONITOR REFERENCES
0C28:    *
0024:    CH       EQU   $24        ;HORIZONTAL TAB LOCATION
0025:    CV       EQU   $25        ;VERTICAL TAB LOCATION
0038:    KSW      EQU   $38        ;KEYBOARD SWITCH
008D:    CR       EQU   $8D        ;CARRIAGE RETURN
C010:    KBDSTB   EQU   $C010      ;KEYBOARD STROBE
FC58:    HOME     EQU   $FC58      ;CLEAR SCREEN
FC22:    VTAB     EQU   $FC22      ;VERTICAL TAB
FD0C:    RDKEY    EQU   $FD0C      ;READ KEY ROUTINE
FD1B:    KEYIN    EQU   $FD1B      ;KEY INPUT ROUTINE
FDF0:    COUT1    EQU   $FDF0      ;OUTPUT CHARACTER
FE80:    SETINV   EQU   $FE80      ;INVERSE SCREEN
FE84:    SETNRM   EQU   $FE84      ;NORMAL SCREEN
0C28:    *
0C28:    *  ZERO PAGE VARIABLES
0C28:    *
0000:             DSECT
00F9:             ORG   $F9
00F9:    ADDRES   DS    2          ;TRANSMIT ADDRESS VECTOR
00FB:    BYTES1   DS    2          ;TRANSMIT BYTE COUNTER
00FD:    PRTADD   DS    2          ;PRINTING ADDRESS VECTOR
00FF:    TLBTCT   DS    1          ;TEMPORARY TRANSMIT BYTE COUNTER
0C28:             DEND
0C28:    *
0C28:    *  GENERAL VARIABLES
0C28:    *
0000:             DSECT
0C00:             ORG   $0C00
0C00:    REPNUM   DS    1          ;LASER REP NUMBER
0C01:    MSHOTS   DS    2          ;SHOTS/PROFILE (MAX=32767)
0C03:    *
0C03:    ACKFLG   DS    1          ;ACKNOWLEDGE FLAG
0C04:    DATOPC   DS    1          ;TRANSMIT OPCODE STORAGE
0C05:    ERRORS   DS    1          ;ERROR COUNTER
0C06:    LSTFLG   DS    1          ;LAST PAGE TRANSMIT FLAG
0C07:    OPCDE    DS    1          ;RECVD OPCODE STORAGE
0C08:    *
0C08:    COUNT1   DS    2          ;TEMP. TRANSMIT BYTE COUNTER
0C0A:    RCSUM    DS    2          ;RECVD CHECKSUM
0C0C:    SAVADD   DS    2          ;PLACE TO SAVE ADDRESS
0C0E:    SAVSUM   DS    2          ;PLACE TO SAVE CHECKSUM
0C10:    STATE    DS    2          ;INPUT BYTE VECTOR
0C12:    TSHOT    DS    2          ;SHOT COUNTER
0C14:    XCSUM    DS    2          ;TRANSMIT CHECKSUM
0C28:             DEND
0C28:    *
0C28:    **********************************
0C28:    *
0C28:    *  MAIN PROGRAM LOOP
0C28:    *
0C28:    **********************************
0C28:    *
```

```
0C28:              *  INITIALIZE RECEIVER
0C28:              *
0C28:A9 1B                 LDA  #>KEYIN    ;LOAD KEYBOARD SWITCH
0C2A:85 38                 STA  KSW
0C2C:A9 FD                 LDA  #<KEYIN
0C2E:85 39                 STA  KSW+1
0C30:              *
0C30:2C 10 C0              BIT  KBDSTB     ;CLEAR KEYBOARD STROBE
0C33:              *
0C33:20 6C 10              JSR  HEDPRT     ;PRINT HEADING
0C36:              *
0C36:A9 03                 LDA  #03        ;MASTER RESET ACIA
0C38:8D A0 C0              STA  CSR
0C3B:A9 95                 LDA  #$95       ;SET UP ACIA
0C3D:8D A0 C0              STA  CSR
0C40:              *
0C40:A9 5E                 LDA  #>IOINT    ;SET INTERRUPT VECTOR
0C42:8D FE 03              STA  INTV       ;  FOR IOINT
0C45:A9 0C                 LDA  #<IOINT
0C47:8D FF 03              STA  INTV+1
0C4A:              *
0C4A:A9 8C                 LDA  #>STPAK1   ;SET INPUT BYTE VECTOR
0C4C:8D 10 0C              STA  STATE
0C4F:A9 0C                 LDA  #<STPAK1
0C51:8D 11 0C              STA  STATE+1
0C54:              *
0C54:58                    CLI             ;CLEAR INTERRUPT BIT
0C55:20 B6 10              JSR  IDLPRT     ;PRINT 'IDLE'
0C58:              *
0C58:EA              WLOOP NOP             ;IDLE LOOP
0C59:EA                    NOP
0C5A:EA                    NOP
0C5B:4C 58 0C              JMP  WLOOP
0C5E:              *
0C5E:              ********************************
0C5E:              *
0C5E:              *  APPLE RECEIVER
0C5E:              *
0C5E:              ********************************
0C5E:              *
0C5E:              *  INTERRUPT ENTRY POINT
0C5E:              *
0C5E:78              IOINT SEI             ;DISABLE INTERRUPT
0C5F:20 4A FF              JSR  IOSAVE     ;SAVE REGISTERS
0C62:AD A0 C0              LDA  CSR        ;CLEAR INTR BIT IN CSR
0C65:AD A1 C0              LDA  XRDR       ;LOAD ACCUM WITH INPUT BYTE
0C68:6C 10 0C              JMP  (STATE)    ;GO TAKE CARE OF INPUT BYTE
0C6B:              *
0C6B:              *  INTERRUPT EXIT POINT
0C6B:              *
0C6B:18              GETBT CLC             ;UPDATE RECD CHECKSUM
0C6C:6D 0A 0C              ADC  RCSUM      ;  LO BYTE
0C6F:90 03                 BCC  SKUPRC
0C71:EE 0B 0C              INC  RCSUM+1    ;  HI BYTE
0C74:8D 0A 0C       SKUPRC STA  RCSUM
0C77:              *
```

```
0C77:18                  CLC               ;SET NEW INPUT BYTE VECTOR
0C78:68                  PLA               ;  PULL LO ADDRESS( -1)
0C79:69 01               ADC  #1
0C7B:8D 10 0C            STA  STATE
0C7E:68                  PLA               ;  PULL HI ADDRESS
0C7F:69 00               ADC  #0
0C81:8D 11 0C            STA  STATE+1
0C84:           *
0C84:20 3F FF            JSR  IOREST       ;RESTORE REGISTERS
0C87:58                  CLI               ;ENABLE INTERRUPT
0C88:40                  RTI
0C89:           *
0C89:           *---------------------------------
0C89:           *  PACKET RECEIVING
0C89:           *---------------------------------
0C89:20 6B 0C   STPAK    JSR  GETBT
0C8C:C9 90      STPAK1   CMP  #DLE         ;CHECK FOR 'DLE' BYTE
0C8E:D0 F9               BNE  STPAK
0C90:           *
0C90:20 6B 0C            JSR  GETBT
0C93:C9 83               CMP  #STX         ;CHECK FOR 'STX' BYTE
0C95:D0 F2               BNE  STPAK
0C97:A2 00               LDX  #0           ; ZERO RECD CHECKSUM
0C99:8E 0A 0C            STX  RCSUM
0C9C:8E 0B 0C            STX  RCSUM+1
0C9F:           *
0C9F:20 6B 0C            JSR  GETBT        ;GET OPCODE
0CA2:8D 07 0C            STA  OPCDE        ;  SAVE IT
0CA5:           *
0CA5:           *  VERIFY CHECKSUM
0CA5:           *
0CA5:20 6B 0C   VERCHK   JSR  GETBT        ;GET 'DLE' BYTE
0CA8:20 6B 0C            JSR  GETBT        ;GET 'ETX' BYTE
0CAB:AE 0A 0C   VERIFY   LDX  RCSUM        ;SAVE LO BYTE RECD CHECKSUM
0CAE:8E 0E 0C            STX  SAVSUM
0CB1:AE 0B 0C            LDX  RCSUM+1      ;SAVE HI BYTE RECD CHECKSUM
0CB4:8E 0F 0C            STX  SAVSUM+1
0CB7:           *
0CB7:20 6B 0C            JSR  GETBT        ;GET LO BYTE XMITTED CHECKSUM
0CBA:CD 0E 0C            CMP  SAVSUM       ;  CHECK IT
0CBD:D0 CA               BNE  STPAK
0CBF:           *
0CBF:20 6B 0C            JSR  GETBT        ;GET HI BYTE XMITTED CHECKSUM
0CC2:CD 0F 0C            CMP  SAVSUM+1     ;  CHECK IT
0CC5:D0 C2               BNE  STPAK
0CC7:           *
0CC7:           *  DECIPHER OPCODE
0CC7:           *
0CC7:AD 07 0C            LDA  OPCDE        ;LOAD OPCODE
0CCA:C9 34               CMP  #ACK         ;  ACK ?
0CCC:F0 18               BEQ  ACKN
0CCE:C9 32               CMP  #COM         ;  COMMANDS ?
0CD0:F0 1C               BEQ  COMN
0CD2:C9 45               CMP  #COMEND      ;  COMMAND PACKET COMPLETED ?
0CD4:D0 06               BNE  CHKDTR       ;  -NO,GO ON
0CD6:20 1E 0D            JSR  SNDACK       ;  -YES,SEND ACK
```

```
0CD9:4C B9 0C            JMP  STPAK
0CDC:C9 31      CHKDTR   CMP  #DRUN      ;  DATA RUN ?
0CDE:D0 A9               BNE  STPAK      ;  -NO,BAD OPCODE
0CE0:20 1E 0D            JSR  SNDACK     ;  -YES,SEND ACK
0CE3:4C A6 0E            JMP  DATRUN     ;   JUMP TO DATA RUN
0CE6:           *
0CE6:           *--------------------------------
0CE6:           *  RECEIVED ACKNOWLEDGE
0CE6:           *--------------------------------
0CE6:A9 01      ACKN     LDA  #1         ;SET ACK FLAG
0CE8:8D 03 0C            STA  ACKFLG
0CEB:4C 89 0C            JMP  STPAK
0CEE:           *
0CEE:           *
0CEE:           *--------------------------------
0CEE:           *  RECEIVE COMMANDS
0CEE:           *--------------------------------
0CEE:A9 45      COMN     LDA  #COMEND    ;STORE 'COMMANDS COMPLETED' OPC
0CF0:8D 07 0C            STA  OPCDE
0CF3:20 6B 0C            JSR  GETBT
0CF6:C9 90               CMP  #DLE       ;CHECK FOR 'DLE' BYTE
0CF8:D0 8F               BNE  STPAK
0CFA:           *
0CFA:20 6B 0C            JSR  GETBT
0CFD:C9 81               CMP  #CTX       ;CHECK FOR 'CTX' BYTE
0CFF:D0 88               BNE  STPAK
0D01:A2 00               LDX  #0         ; ZERO RECD CHECKSUM
0D03:8E 0A 0C            STX  RCSUM
0D06:8E 0B 0C            STX  RCSUM+1
0D09:           *
0D09:20 6B 0C            JSR  GETBT      ;GET LASER REP NUMBER
0D0C:8D 00 0C            STA  REPNUM
0D0F:20 6B 0C            JSR  GETBT      ;GET LO BYTE SHOTS/PROF
0D12:8D 01 0C            STA  MSHOTS
0D15:20 6B 0C            JSR  GETBT      ;GET HI BYTE SHOTS/PROF
0D18:8D 02 0C            STA  MSHOTS+1
0D1B:4C A5 0C            JMP  VERCHK
0D1E:           *
0D1E:           ********************************
0D1E:           *
0D1E:           *  APPLE SENDER
0D1E:           *
0D1E:           ********************************
0D1E:           *
0D1E:           *================================
0D1E:           *  SEND ACKNOWLEDGE
0D1E:           *================================
0D1E:A9 34      SNDACK   LDA  #ACK       ;LOAD ACK OPCODE
0D20:8D 04 0C            STA  DATOPC
0D23:20 5C 0E            JSR  SNDFRM     ;SEND ACK FRAME
0D26:60                  RTS
0D27:           *
0D27:           *================================
0D27:           *  SEND PROFILE DONE FRAME
0D27:           *================================
0D27:58         SNDPRD   CLI
```

```
0D28:A9 33             LDA  #PRDONE   ;LOAD 'PRDONE' OPCODE
0D2A:8D 04 0C          STA  DATOPC
0D2D:A9 03             LDA  #ERRCNT   ;LOAD ERROR COUNT REG
0D2F:8D 05 0C          STA  ERRORS
0D32:58                CLI
0D33:            *
0D33:A9 00       SNDPR1 LDA  #0        ;CLEAR ACK FLAG
0D35:8D 03 0C          STA  ACKFLG
0D38:20 5C 0E          JSR  SNDFRM    ;SEND PROFILE DONE FRAME
0D3B:            *
0D3B:A0 32             LDY  #DEL1     ;WAIT FOR ACK
0D3D:A9 10       ACKWT1 LDA  #16
0D3F:20 A8 FC          JSR  WAIT      ;  DELAY
0D42:AD 03 0C          LDA  ACKFLG    ;  CHECK ACK FLAG
0D45:D0 0B             BNE  OKACK1
0D47:88                DEY
0D48:D0 F3             BNE  ACKWT1
0D4A:CE 05 0C    ERRCK1 DEC  ERRORS
0D4D:D0 E4             BNE  SNDPR1
0D4F:4C F7 0F          JMP  ERRPRT
0D52:            *
0D52:60          OKACK1 RTS
0D53:            *================================
0D53:            *  SEND DATA PACKETS
0D53:            *================================
0D53:            *
0D53:            *  SEND LO BYTE DATA
0D53:            *
0D53:20 EA 10    SNDDAT JSR  TDPRT     ;PRINT 'TRANSMITTING DATA'
0D56:58                CLI
0D57:A9 50             LDA  #OPCLO    ;LOAD BASE OPCODE
0D59:8D 04 0C          STA  DATOPC
0D5C:            *
0D5C:A9 00             LDA  #>STADDL  ;LOAD STARTING ADDRESS
0D5E:85 F9             STA  ADDRES
0D60:A9 90             LDA  #<STADDL
0D62:85 FA             STA  ADDRES+1
0D64:            *
0D64:A9 D0             LDA  #>BYTCNT  ;LOAD BYTE COUNT
0D66:85 FB             STA  BYTES1
0D68:A9 07             LDA  #<BYTCNT
0D6A:85 FC             STA  BYTES1+1
0D6C:            *
0D6C:20 8B 0D          JSR  DATOUT    ;GO SEND LO BYTES
0D6F:            *
0D6F:            *  SEND HI BYTE DATA
0D6F:            *
0D6F:A9 E0             LDA  #OPCHI    ;LOAD BASE OPCODE
0D71:8D 04 0C          STA  DATOPC
0D74:            *
0D74:A9 00             LDA  #>STADDH  ;LOAD STARTING ADDRESS
0D76:85 F9             STA  ADDRES
0D78:A9 98             LDA  #<STADDH
0D7A:85 FA             STA  ADDRES+1
0D7C:            *
0D7C:A9 D0             LDA  #>BYTCNT  ;LOAD BYTE COUNT
```

```
0D7E:85 FB                   STA  BYTES1
0D80:A9 07                   LDA  #<BYTCNT
0D82:85 FC                   STA  BYTES1+1
0D84:              *
0D84:20 8B 0D                JSR  DATOUT    ;GO SEND HI BYTES
0D87:              *
0D87:20 27 0D                JSR  SNDPRD    ;GO SEND 'PROFILE DONE' FRAME
0D8A:              *
0D8A:60            DDONE     RTS
0D8B:              *
0D8B:              *-------------------------------
0D8B:              *  DATA PACKET SENDING ROUTINE
0D8B:              *-------------------------------
0D8B:              *
0D8B:              *  CHECK FOR LAST PACKET (SET LAST PACKET FLAG)
0D8B:              *
0D8B:A9 00         DATOUT    LDA  #0        ;INITIALIZE LAST PACKET FLAG
0D8D:8D 06 0C                STA  LSTFLG
0D90:              *
0D90:A9 07         DTOUT1    LDA  #<PAKLEN  ;  CHECK HI BYTE
0D92:C5 FC                   CMP  BYTES1+1
0D94:F0 05                   BEQ  CHKLO
0D96:90 1B                   BCC  FULPAK
0D98:4C A1 0D                JMP  SETFLG
0D9B:A9 D0         CHKLO     LDA  #>PAKLEN  ;  CHECK LO BYTE
0D9D:C5 FB                   CMP  BYTES1
0D9F:90 12                   BCC  FULPAK
0DA1:              *
0DA1:A9 01         SETFLG    LDA  #1        ;SET LAST PACKET FLAG
0DA3:8D 06 0C                STA  LSTFLG
0DA6:              *
0DA6:A5 FB                   LDA  BYTES1    ;SET BYTE COUNT FOR LAST PACKET
0DA8:8D 08 0C                STA  COUNT1
0DAB:A5 FC                   LDA  BYTES1+1
0DAD:8D 09 0C                STA  COUNT1+1
0DB0:4C BD 0D                JMP  PAKOUT
0DB3:              *
0DB3:A9 D0         FULPAK    LDA  #>PAKLEN  ;SET BYTE COUNT FOR FULL PACKET
0DB5:8D 08 0C                STA  COUNT1
0DB8:A9 07                   LDA  #<PAKLEN
0DBA:8D 09 0C                STA  COUNT1+1
0DBD:              *
0DBD:              *  SEND ONE PACKET
0DBD:              *
0DBD:A9 03         PAKOUT    LDA  #ERRCNT   ;INITIALIZE ERROR COUNT REGISTER
0DBF:8D 05 0C                STA  ERRORS
0DC2:A9 00         PAKOT1    LDA  #0        ;INITIALIZE ACK FLAG
0DC4:8D 03 0C                STA  ACKFLG
0DC7:              *
0DC7:20 5C 0E                JSR  SNDFRM    ;SEND DATA FRAME PART 1
0DCA:20 0C 0E                JSR  SNDPK2    ;SEND DATA FRAME PART 2
0DCD:              *
0DCD:A0 32                   LDY  #DEL1     ;WAIT FOR ACK FLAG
0DCF:A9 10         ACKWT2    LDA  #16
0DD1:20 A8 FC                JSR  WAIT      ;  DELAY
0DD4:AD 03 0C                LDA  ACKFLG    ;  CHECK ACKFLAG
```

```
0DD7:D0 0B      382          BNE  OKACK2
0DD9:88         383          DEY
0DDA:D0 F3      384          BNE  ACKWT2
0DDC:           385 *
0DDC:CE 05 0C   386 ERRCK2   DEC  ERRORS
0DDF:D0 E1      387          BNE  PAKUT1
0DE1:4C F7 0F   388          JMP  ERRPRT
0DE4:           389 *
0DE4:           390 *  CHECK LAST PACKET FLAG
0DE4:           391 *
0DE4:AD 06 0C   392 OKACK2   LDA  LSTFLG    ;LAST PACKET DONE ?
0DE7:C9 01      393          CMP  #1
0DE9:F0 20      394          BEQ  DONE      ; -YES,GOTO DONE
0DEB:           395 *
0DEB:           396 *  DETERMINE NEW STARTING ADDRESS, BYTE COUNT, & OPCODE
0DEB:           397 *
0DEB:18         398 NEWADD   CLC            ;NEW ADDRESS
0DEC:A9 D0      399          LDA  #>PAKLEN  ;  LO BYTE
0DEE:65 F9      400          ADC  ADDRES
0DF0:85 F9      401          STA  ADDRES
0DF2:           402 *
0DF2:A9 07      403          LDA  #<PAKLEN  ;  HI BYTE
0DF4:65 FA      404          ADC  ADDRES+1
0DF6:85 FA      405          STA  ADDRES+1
0DF8:           406 *
0DF8:38         407          SEC            ;NEW BYTE COUNT
0DF9:A5 FB      408          LDA  BYTES1    ;  LO BYTE
0DFB:E9 D0      409          SBC  #>PAKLEN
0DFD:85 FB      410          STA  BYTES1
0DFF:           411 *
0DFF:A5 FC      412          LDA  BYTES1+1  ;  HI BYTE
0E01:E9 07      413          SBC  #<PAKLEN
0E03:85 FC      414          STA  BYTES1+1
0E05:           415 *
0E05:EE 04 0C   416          INC  DATOPC    ;NEW OPCODE
0E08:4C 90 0D   417          JMP  DTOUT1    ;SEND NEXT PACKET
0E0B:           418 *
0E0B:60         419 DONE     RTS            ;DATA BLOCK SENDING COMPLETE
0E0C:           420 *
0E0C:           421 *-------------------------------
0E0C:           422 *  DATA PACKET PART 2
0E0C:           423 *  SENDING ROUTINE
0E0C:           424 *-------------------------------
0E0C:A5 FA      425 SNDPK2   LDA  ADDRES+1  ;SAVE HI BYTE OF ADDRESS
0E0E:8D 0C 0C   426          STA  SAVADD
0E11:           427 *
0E11:A9 90      428          LDA  #DLE
0E13:20 99 0E   429          JSR  SNDBYT    ;SEND 'DLE' CHARACTER
0E16:A9 00      430          LDA  #0        ;CLEAR XMIT CHECKSUM
0E18:8D 14 0C   431          STA  XCSUM
0E1B:8D 15 0C   432          STA  XCSUM+1
0E1E:           433 *
0E1E:A9 81      434          LDA  #CTX
0E20:20 8B 0E   435          JSR  UPDTCK    ;UPDATE XMIT CHECKSUM & SEND 'CTX'
0E23:           436 *
0E23:AE 09 0C   437          LDX  COUNT1+1
```

```
0E26:A0 00          SENDPG  LDY  #0
0E28:E0 00                  CPX  #0          ;LAST PAGE TO BE SENT ?
0E2A:F0 11                  BEQ  LASTPG      ; -YES,SEND LAST PAGE
0E2C:10 08                  BPL  FULLPG      ; -NO,SEND FULL PAGE
0E2E:AD 0C 0C               LDA  SAVADD      ; -PACKET COMPLETED
0E31:85 FA                  STA  ADDRES+1    ;   RESTORE INITIAL ADDRESS
0E33:4C 74 0E               JMP  ENDER       ;   SEND PACKET ENDER
0E36:               *
0E36:A9 00          FULLPG  LDA  #0          ;SET BYTE COUNT FOR FULL PAGE
0E38:85 FF                  STA  TLBTCT
0E3A:4C 46 0E               JMP  SNDIT1
0E3D:               *
0E3D:AD 08 0C       LASTPG  LDA  COUNT1      ;SET BYTE COUNT FOR LAST PAGE
0E40:85 FF                  STA  TLBTCT
0E42:               *
0E42:C4 FF          SENDIT  CPY  TLBTCT      ;LAST BYTE OF PAGE SENT ?
0E44:F0 10                  BEQ  NEXTPG      ; -YES,SET UP FOR NEXT PAGE
0E46:B1 F9          SNDIT1  LDA  (ADDRES),Y ;-NO,SEND ANOTHER
0E48:20 8B 0E               JSR  UPDTCK
0E4B:C9 90                  CMP  #DLE        ;DATA = 'DLE' BYTE ?
0E4D:D0 03                  BNE  SKDBL       ; -NO,SKIP DOUBLE 'DLE'
0E4F:20 8B 0E               JSR  UPDTCK      ; -YES,SEND SECOND 'DLE'
0E52:C8             SKDBL   INY
0E53:4C 42 0E               JMP  SENDIT      ;GO TO SEND ANOTHER BYTE
0E56:               *
0E56:CA             NEXTPG  DEX
0E57:E6 FA                  INC  ADDRES+1    ;SET ADDRESS FOR NEXT PAGE
0E59:4C 26 0E               JMP  SENDPG
0E5C:               *
0E5C:               *--------------------------------
0E5C:               *  HEADER PACKET SENDING ROUTINE
0E5C:               *--------------------------------
0E5C:A9 90          SNDFRM  LDA  #DLE
0E5E:20 99 0E               JSR  SNDBYT      ;SEND 'DLE' CHARACTER
0E61:A9 00                  LDA  #0          ;CLEAR XMIT CHECKSUM
0E63:8D 14 0C               STA  XCSUM
0E66:8D 15 0C               STA  XCSUM+1
0E69:               *
0E69:A9 83                  LDA  #STX
0E6B:20 8B 0E               JSR  UPDTCK      ;UPDATE XMIT CHECKSUM & SEND 'STX'
0E6E:               *
0E6E:AD 04 0C               LDA  DATOPC
0E71:20 8B 0E               JSR  UPDTCK      ;UPDATE XMIT CHECKSUM & SEND OPCODE
0E74:               *
0E74:A9 90          ENDER   LDA  #DLE
0E76:20 8B 0E               JSR  UPDTCK      ;UPDATE XMIT CHECKSUM & SEND 'DLE'
0E79:               *
0E79:A9 82                  LDA  #ETX
0E7B:20 99 0E               JSR  SNDBYT      ;SEND 'ETX' CHARACTER
0E7E:               *
0E7E:AD 14 0C       SNDCHK  LDA  XCSUM       ;SEND XMIT CHECKSUM
0E81:20 99 0E               JSR  SNDBYT      ;  LO BYTE
0E84:AD 15 0C               LDA  XCSUM+1
0E87:20 99 0E               JSR  SNDBYT      ;  HI BYTE
0E8A:               *
0E8A:60                     RTS
```

```
0EBB:              *
0EBB:              *-------------------------------
0EBB:              *  UPDATE CHECKSUM & SEND BYTE
0EBB:              *           ROUTINES
0EBB:              *-------------------------------
0EBB:48            UPDTCK  PHA               ;SAVE BYTE
0EBC:18                    CLC
0EBD:6D 14 0C              ADC  XCSUM        ;UPDATE CHECKSUM
0E90:90 03                 BCC  SKUPXC
0E92:EE 15 0C              INC  XCSUM+1
0E95:8D 14 0C      SKUPXC  STA  XCSUM
0E98:68                    PLA               ;RESTORE BYTE
0E99:              *
0E99:48            SNDBYT  PHA               ;SAVE BYTE
0E9A:AD A0 C0      LOOP1   LDA  CSR          ;CHECK ACIA STATUS
0E9D:29 02                 AND  #2
0E9F:F0 F9                 BEQ  LOOP1
0EA1:              *
0EA1:68                    PLA               ;RESTORE BYTE
0EA2:8D A1 C0              STA  XRDR         ;SEND BYTE
0EA5:60                    RTS
0EA6:              *
0EA6:              ********************************
0EA6:              *
0EA6:              *  DATA RUN
0EA6:              *
0EA6:              ********************************
0EA6:              *
0EA6:20 D0 10      DATRUN  JSR  TKPPRT
0EA9:AD 01 0C              LDA  MSHOTS       ;LOAD SHOT COUNTER TSHOT
0EAC:8D 12 0C              STA  TSHOT
0EAF:AD 02 0C              LDA  MSHOTS+1
0EB2:8D 13 0C              STA  TSHOT+1
0EB5:              *
0EB5:A9 00                 LDA  #0           ;CHECK LO BYTE SHOT COUNT
0EB7:CD 12 0C              CMP  TSHOT        ;  = 0 ?
0EBA:D0 03                 BNE  IDMAC        ;  -NO,GO ON
0EBC:CE 13 0C              DEC  TSHOT+1      ;  -YES,DEC HI BYTE SHOT COUNT
0EBF:              *------------------------------
0EBF:              *  INITIALIZE DMAC
0EBF:              *------------------------------
0EBF:A9 60         IDMAC   LDA  #<BUFADD     ;LOAD ADDRESS HI BYTE
0EC1:8D 04 C4              STA  DMAREG+4     ;  CHANNEL 1
0EC4:8D 0C C4              STA  DMAREG+12    ;  CHANNEL 3
0EC7:A9 00                 LDA  #>BUFADD     ;LOAD ADDRESS LO BYTE
0EC9:8D 05 C4              STA  DMAREG+5     ;  CHANNEL 1
0ECC:8D 0D C4              STA  DMAREG+13    ;  CHANNEL 3
0ECF:A9 07                 LDA  #$07         ;LOAD COUNT HI BYTE
0ED1:8D 06 C4              STA  DMAREG+6     ;  CHANNEL 1
0ED4:8D 0E C4              STA  DMAREG+14    ;  CHANNEL 3
0ED7:A9 D1                 LDA  #$D1         ;LOAD COUNT LO BYTE
0ED9:8D 07 C4              STA  DMAREG+7     ;  CHANNEL 1
0EDC:8D 0F C4              STA  DMAREG+15    ;  CHANNEL 3
0EDF:A9 02                 LDA  #2           ;LOAD CHANNEL CONTROL
0EE1:8D 11 C4              STA  DMAREG+17
0EE4:A9 0C                 LDA  #0           ;LOAD INTERRUPT CONTROL
```

```
0EE6:8D 15 C4           STA  DMAREG+21
0EE9:A9 03              LDA  #3         ;LOAD DATA CHAIN
0EEB:8D 16 C4           STA  DMAREG+22
0EEE:A9 02              LDA  #2         ;LOAD PRIORITY CONTROL
0EF0:8D 14 C4           STA  DMAREG+20
0EF3:              *-------------------------------
0EF3:              *  INIT MAINFRAME MEMORY
0EF3:              *-------------------------------
0EF3:A9 00              LDA  #>STADDL   ;LOAD STARTING ADDRESS
0EF5:85 FD              STA  PRTADD
0EF7:A9 90              LDA  #<STADDL
0EF9:85 FE              STA  PRTADD+1
0EFB:              *
0EFB:A2 10              LDX  #16        ;LOAD X WITH 16 (PAGES)
0EFD:A9 00              LDA  #0         ;CLEAR A & Y
0EFF:A8                 TAY
0F00:              *
0F00:91 FD         CLRLP   STA  (PRTADD),Y ;CLEAR MEMORY
0F02:C8                 INY
0F03:D0 FB              BNE  CLRLP
0F05:E6 FE              INC  PRTADD+1
0F07:CA                 DEX
0F08:D0 F6              BNE  CLRLP
0F0A:              *-------------------------------
0F0A:              *  FIRE LASER & CHECK FOR
0F0A:              *       DMA DONE
0F0A:              *-------------------------------
0F0A:8D C1 C0      TRIG1   STA  TRIG       ;FIRE  LASER
0F0D:EA                 NOP
0F0E:EA                 NOP
0F0F:EA                 NOP
0F10:A9 04              LDA  #4         ;'WAIT' DURING DMA
0F12:20 A8 FC           JSR  WAIT
0F15:2C 11 C4           BIT  DMAREG+17  ;DMA BIT SET ?
0F18:30 0C              BMI  INTGRT     ; -YES,GOTO INTGRT
0F1A:8D C4 C0           STA  SLPRST     ; -NO,RESET SLIPP INTERFACE
0F1D:20 3A 10           JSR  TRGPRT     ;  PRINT ERROR MESSAGE
0F20:20 D0 10           JSR  TKPPRT
0F23:4C 0A 0F           JMP  TRIG1
0F26:              *-------------------------------
0F26:              *  INTEGRATION
0F26:              *-------------------------------
0F26:A0 00         INTGRT  LDY  #0         ;INIT Y
0F28:18            ADD0    CLC             ;FIRST PAGE ADDITION
0F29:B9 00 60           LDA  BUFADD,Y   ; LOW BYTE ADD
0F2C:79 00 90           ADC  STADDL,Y
0F2F:99 00 90           STA  STADDL,Y
0F32:A9 00              LDA  #0         ; HIGH BYTE ADD
0F34:79 00 98           ADC  STADDH,Y
0F37:99 00 98           STA  STADDH,Y
0F3A:18            ADD1    CLC             ;SECOND PAGE ADDITIONS
0F3B:B9 00 61           LDA  BUFADD+$100,Y
0F3E:79 00 91           ADC  STADDL+$100,Y
0F41:99 00 91           STA  STADDL+$100,Y
0F44:A9 00              LDA  #0
0F46:79 00 99           ADC  STADDH+$100,Y
```

```
0F49:99 00 99            STA   STADDH+$100,Y
0F4C:18          ADD2    CLC               ;THIRD PAGE ADDITIONS
0F4D:B9 00 62            LDA   BUFADD+$200,Y
0F50:79 00 92            ADC   STADDL+$200,Y
0F53:99 00 92            STA   STADDL+$200,Y
0F56:A9 00               LDA   #0
0F58:79 00 9A            ADC   STADDH+$200,Y
0F5B:99 00 9A            STA   STADDH+$200,Y
0F5E:18          ADD3    CLC               ;FORTH PAGE ADDITIONS
0F5F:B9 00 63            LDA   BUFADD+$300,Y
0F62:79 00 93            ADC   STADDL+$300,Y
0F65:99 00 93            STA   STADDL+$300,Y
0F68:A9 00               LDA   #0
0F6A:79 00 9B            ADC   STADDH+$300,Y
0F6D:99 00 9B            STA   STADDH+$300,Y
0F70:18          ADD4    CLC               ;FIFTH PAGE ADDITIONS
0F71:B9 00 64            LDA   BUFADD+$400,Y
0F74:79 00 94            ADC   STADDL+$400,Y
0F77:99 00 94            STA   STADDL+$400,Y
0F7A:A9 00               LDA   #0
0F7C:79 00 9C            ADC   STADDH+$400,Y
0F7F:99 00 9C            STA   STADDH+$400,Y
0F82:18          ADD5    CLC               ;SIXTH PAGE ADDITIONS
0F83:B9 00 65            LDA   BUFADD+$500,Y
0F86:79 00 95            ADC   STADDL+$500,Y
0F89:99 00 95            STA   STADDL+$500,Y
0F8C:A9 00               LDA   #0
0F8E:79 00 9D            ADC   STADDH+$500,Y
0F91:99 00 9D            STA   STADDH+$500,Y
0F94:18          ADD6    CLC               ;SEVENTH PAGE ADDITIONS
0F95:B9 00 66            LDA   BUFADD+$600,Y
0F98:79 00 96            ADC   STADDL+$600,Y
0F9B:99 00 96            STA   STADDL+$600,Y
0F9E:A9 00               LDA   #0
0FA0:79 00 9E            ADC   STADDH+$600,Y
0FA3:99 00 9E            STA   STADDH+$600,Y
0FA6:18          ADD7    CLC               ;EIGHTH PAGE ADDITIONS
0FA7:B9 00 67            LDA   BUFADD+$700,Y
0FAA:79 00 97            ADC   STADDL+$700,Y
0FAD:99 00 97            STA   STADDL+$700,Y
0FB0:A9 00               LDA   #0
0FB2:79 00 9F            ADC   STADDH+$700,Y
0FB5:99 00 9F            STA   STADDH+$700,Y
0FB8:            *
0FB8:C8                  INY
0FB9:F0 03               BEQ   NXTSHT
0FBB:4C 28 0F            JMP   ADD0
0FBE:            *
0FBE:            *------------------------------
0FBE:            *  CHECK SHOT COUNTER
0FBE:            *     SEND PROFILE
0FBE:            *------------------------------
0FBE:CE 12 0C    NXTSHT  DEC   TSHOT       ;CHECK SHOT COUNTER
0FC1:D0 05               BNE   SKUPTS
0FC3:CE 13 0C            DEC   TSHOT+1
0FC6:30 0E               BMI   PDONE
```

```
0FC8:              *
0FC8:A0 06         SKUPTS  LDY  #6
0FCA:AD 00 0C      RPLOOP  LDA  REPNUM     ;LASER REP DELAY
0FCD:20 A8 FC              JSR  WAIT
0FD0:88                    DEY
0FD1:D0 F7                 BNE  RPLOOP
0FD3:4C 0A 0F              JMP  TRIG1      ;GO FIRE ANOTHER SHOT
0FD6:              *
0FD6:A9 BC         PDONE   LDA  #>STPAK1   ;RESET INPUT BYTE VECTOR
0FD8:8D 10 0C              STA  STATE
0FDB:A9 0C                 LDA  #<STPAK1
0FDD:8D 11 0C              STA  STATE+1
0FE0:              *
0FE0:20 53 0D              JSR  SNDDAT     ;SEND DATA
0FE3:20 B6 10              JSR  IDLPRT     ;PRINT 'IDLE'
0FE6:4C 89 0C              JMP  STPAK
0FE9:              *
0FE9:              ********************************
0FE9:              *
0FE9:              *  PRINTING ROUTINES
0FE9:              *
0FE9:              ********************************
0FE9:              *
0FE9:              *  PRINT SUBROUTINE
0FE9:              *
0FE9:A0 00         PRINT   LDY  #0
0FEB:B1 FD         PRINT1  LDA  (PRTADD),Y
0FED:F0 07                 BEQ  ENDP
0FEF:20 F0 FD              JSR  COUT1
0FF2:C8                    INY
0FF3:4C EB 0F              JMP  PRINT1
0FF6:60            ENDP    RTS
0FF7:              *-------------------------------
0FF7:              *  DATA TRANSMISSION ERROR MESSAGE
0FF7:              *-------------------------------
0FF7:20 58 FC      ERRPRT  JSR  HOME       ;CLEAR SCREEN
0FFA:              *
0FFA:A9 0A                 LDA  #10        ;SET VERTICAL TAB
0FFC:85 25                 STA  CV
0FFE:20 22 FC              JSR  VTAB
1001:              *
1001:A9 09                 LDA  #9         ;SET HORIZONTAL TAB
1003:85 24                 STA  CH
1005:20 80 FE              JSR  SETINV     ;SET INVERSE SCREEN
1008:A9 57                 LDA  #ERRMSG
100A:85 FD                 STA  PRTADD
100C:A9 11                 LDA  #<ERRMSG
100E:85 FE                 STA  PRTADD+1
1010:20 E9 0F              JSR  PRINT      ;PRINT ERROR MESSAGE
1013:              *
1013:A9 0A                 LDA  #10        ;SET HORIZONTAL TAB
1015:85 24                 STA  CH
1017:20 84 FE              JSR  SETNRM     ;SET NORMAL SCREEN
101A:A9 72                 LDA  #>TRYAGN
101C:85 FD                 STA  PRTADD
101E:A9 11                 LDA  #<TRYAGN
```

```
1020:85 FE               STA  PRTADD+1
1022:20 E9 0F            JSR  PRINT      ;PRINT TRY AGAIN
1025:              *
1025:20 0C FD            JSR  RDKEY      ;GET RESPONSE
1028:C9 D9               CMP  #'Y
102A:D0 06               BNE  NTAGN
102C:20 58 FC            JSR  HOME
102F:4C 53 0D            JMP  SNDDAT
1032:20 58 FC      NTAGN JSR  HOME
1035:68                  PLA             ;GET OFF STACK
1036:68                  PLA
1037:4C 8A 0D            JMP  DDONE
103A:              *
103A:              *-------------------------------
103A:              *  LASER TRIGGER ERROR MESSAGE
103A:              *-------------------------------
103A:20 58 FC      TRGPRT JSR  HOME
103D:A9 0A               LDA  #10
103F:85 25               STA  CV
1041:20 22 FC            JSR  VTAB
1044:              *
1044:A9 09               LDA  #9
1046:85 24               STA  CH
1048:20 80 FE            JSR  SETINV
104B:A9 85               LDA  #>TGMSG1
104D:85 FD               STA  PRTADD
104F:A9 11               LDA  #<TGMSG1
1051:85 FE               STA  PRTADD+1
1053:20 E9 0F            JSR  PRINT
1056:              *
1056:A9 07               LDA  #7
1058:85 24               STA  CH
105A:20 84 FE            JSR  SETNRM
105D:A9 9F               LDA  #>TGMSG2
105F:85 FD               STA  PRTADD
1061:A9 11               LDA  #<TGMSG2
1063:85 FE               STA  PRTADD+1
1065:20 E9 0F            JSR  PRINT
1068:              *
1068:20 0C FD            JSR  RDKEY
106B:60                  RTS
106C:              *
106C:              *-------------------------------
106C:              *  HEADER MESSAGE
106C:              *-------------------------------
106C:20 58 FC      HEDPRT JSR  HOME
106F:A9 06               LDA  #6
1071:85 25               STA  CV
1073:20 22 FC            JSR  VTAB
1076:              *
1076:A9 0D               LDA  #13
1078:85 24               STA  CH
107A:A9 04               LDA  #>HDMSG1
107C:85 FD               STA  PRTADD
107E:A9 11               LDA  #<HDMSG1
1080:85 FE               STA  PRTADD+1
```

```
1082:20 E9 0F                  JSR  PRINT
1085:                *
1085:A9 08                     LDA  #8
1087:85 24                     STA  CH
1089:A9 15                     LDA  #>HDMSG2
108B:85 FD                     STA  PRTADD
108D:A9 11                     LDA  #<HDMSG2
108F:85 FE                     STA  PRTADD+1
1091:20 E9 0F                  JSR  PRINT
1094:                *
1094:A9 0F                     LDA  #15
1096:85 24                     STA  CH
1098:A9 31                     LDA  #>HDMSG3
109A:85 FD                     STA  PRTADD
109C:A9 11                     LDA  #<HDMSG3
109E:85 FE                     STA  PRTADD+1
10A0:20 E9 0F                  JSR  PRINT
10A3:                *
10A3:A9 08                     LDA  #8
10A5:85 24                     STA  CH
10A7:A9 3E                     LDA  #>HDMSG4
10A9:85 FD                     STA  PRTADD
10AB:A9 11                     LDA  #<HDMSG4
10AD:85 FE                     STA  PRTADD+1
10AF:20 E9 0F                  JSR  PRINT
10B2:                *
10B2:20 0C FD                  JSR  RDKEY
10B5:60                        RTS
10B6:                *-------------------------------
10B6:                *  STATUS MESSAGES
10B6:                *-------------------------------
10B6:                *
10B6:                *  IDLE MESSAGE
10B6:                *
10B6:20 58 FC        IDLPRT    JSR  HOME
10B9:A9 0A                     LDA  #10
10BB:85 25                     STA  CV
10BD:20 22 FC                  JSR  VTAB
10C0:                *
10C0:A9 10                     LDA  #16
10C2:85 24                     STA  CH
10C4:A9 BA                     LDA  #>IDLMSG
10C6:85 FD                     STA  PRTADD
10C8:A9 11                     LDA  #<IDLMSG
10CA:85 FE                     STA  PRTADD+1
10CC:20 E9 0F                  JSR  PRINT
10CF:60                        RTS
10D0:                *
10D0:                *  TAKING PROFILE MESSAGE
10D0:                *
10D0:20 58 FC        TKPPRT    JSR  HOME
10D3:A9 0A                     LDA  #10
10D5:85 25                     STA  CV
10D7:20 22 FC                  JSR  VTAB
10DA:                *
10DA:A9 0A                     LDA  #10
```

```
10DC:85 24               STA  CH
10DE:A9 C3               LDA  #>TKPMSG
10E0:85 FD               STA  PRTADD
10E2:A9 11               LDA  #<TKPMSG
10E4:85 FE               STA  PRTADD+1
10E6:20 E9 0F            JSR  PRINT
10E9:60                  RTS
10EA:               *
10EA:               *  TRANSMITTING DATA MESSAGE
10EA:               *
10EA:20 58 FC       TDPRT    JSR  HOME
10ED:A9 0A               LDA  #10
10EF:85 25               STA  CV
10F1:20 22 FC            JSR  VTAB
10F4:               *
10F4:A9 0A               LDA  #10
10F6:85 24               STA  CH
10F8:A9 D6               LDA  #>TDMSG
10FA:85 FD               STA  PRTADD
10FC:A9 11               LDA  #<TDMSG+1
10FE:85 FE               STA  PRTADD+1
1100:20 E9 0F            JSR  PRINT
1103:60                  RTS
1104:               *
1104:               *-------------------------------
1104:               *  DATA
1104:               *-------------------------------
1104:C1 D0 D0       HDMSG1   ASC  'APPLE    SOFTWARE'
1107:CC C5 A0
110A:D3 CF C6
110D:D4 D7 C1
1110:D2 C5
1112:8D 8D 00            DFB  CR,CR,0
1115:D3 CF C4       HDMSG2   ASC  'SODIUM   LIDAR PREPROCESSOR'
1118:C9 D5 CD
111B:A0 CC C9
111E:C4 C1 D2
1121:A0 D0 D2
1124:C5 D0 D2
1127:CF C3 C5
112A:D3 D3 CF
112D:D2
112E:8D 8D 00            DFB  CR,CR,0
1131:B2 B0 AD       HDMSG3   ASC  '20-FEB-83'
1134:C6 C5 C2
1137:AD B8 B3
113A:8D 8D 8D            DFB  CR,CR,CR,0
113D:00
113E:BC A0 D0       HDMSG4   ASC  '<         PRESS A KEY TO BEGIN >'
1141:D2 C5 D3
1144:D3 A0 C1
1147:A0 CB C5
114A:D9 A0 D4
114D:CF A0 C2
1150:C5 C7 C9
1153:CE A0 BE
```

```
1156:00         864         DFB  0
1157:C4 C1 D4   865 ERRMSG  ASC  'DATA     TRANSMISSION ERROR'
115A:C1 A0 D4
115D:D2 C1 CE
1160:D3 CD C9
1163:D3 D3 C9
1166:CF CE A0
1169:C5 D2 D2
116C:CF D2
116E:8D 8D 8D   866         DFB  CR,CR,CR,0
1171:00
1172:D4 D2 D9   867 TRYAGN  ASC  'TRY      SENDING AGAIN?'
1175:A0 D3 C5
1178:CE C4 C9
117B:CE C7 A0
117E:C1 C7 C1
1181:C9 CE BF
1184:00         868         DFB  0
1185:CC C1 D3   869 TGMSG1  ASC  'LASER    TRIGGER ERROR'
1188:C5 D2 A0
118B:D4 D2 C9
118E:C7 C7 C5
1191:D2 A0 D3
1194:C3 D2 C5
1197:D7 AD D5
119A:D0
119B:8D 8D 8D   870         DFB  CR,CR,CR,0
119E:00
119F:BC D0 D2   871 TGMSG2  ASC  '<PRESS   A KEY TO TRY AGAIN>'
11A2:C5 D3 D3
11A5:A0 C1 A0
11A8:CB C5 D9
11AB:A0 D4 CF
11AE:A0 D4 D2
11B1:D9 A0 C1
11B4:C7 C1 C9
11B7:CE BE
11B9:00         872         DFB  0
11BA:BC A0 C9   873 IDLMSG  ASC  '<        IDLE >'
11BD:C4 CC C5
11C0:A0 BE
11C2:00         874         DFB  0
11C3:BC A0 D4   875 TKPMSG  ASC  '<        TAKING PROFILE >'
11C6:C1 CB C9
11C9:CE C7 A0
11CC:D0 D2 CF
11CF:C6 C9 CC
11D2:C5 A0 BE
11D5:00         876         DFB  0
11D6:BC A0 D4   877 TDMSG   ASC  '<        TRANSMITTING DATA >'
11D9:D2 C1 CE
11DC:D3 CD C9
11DF:D4 D4 C9
11E2:CE C7 A0
11E5:C4 C1 D4
11E8:C1 A0 BE
11EB:00         878         DFB  0
```

0C03	ACKFLG	0CE6	ACKN	0D3D	ACKWT1	0DCF	ACKWT2
34	ACK	0F28	ADD0	?0F3A	ADD1	?0F4C	ADD2
?0F5E	ADD3	?0F70	ADD4	?0F82	ADD5	?0F94	ADD6
?0FA6	ADD7	F9	ADDRES	6000	BUFADD	07D0	BYTCNT
FB	BYTES1	24	CH	0CDC	CHKDTR	0D9B	CHKLO
0F00	CLRLP	32	COM	45	COMEND	0CEE	COMN
0C08	COUNT1	FDF0	COUT1	8D	CR	C0A0	CSR
81	CTX	25	CV	0C04	DATOPC	0D[illegible]B	DATOUT
0EA6	DATRUN	0D8A	DDONE	32	DEL1	[illegible]	DLE
C400	DMAREG	0E0B	DONE	31	DRUN	0D90	DTOUT1
0E74	ENDER	0FF6	ENDP	?0D4A	ERRCK1	?0DDC	ERRCK2
03	ERRCNT	1157	ERRMSG	0C05	ERRORS	0FF7	ERRPRT
82	ETX	0C36	FULLPG	0DB3	FULPAK	0C6B	SETP[illegible]
1104	HDMSG1	1115	HDMSG2	1131	HDMSG3	113E	HDMSG4
106C	HEDPRT	FC58	HOME	11BA	IDLMSG	10B6	IDLPRT
0EBF	IDMAC	0F26	INTGRT	03FE	INTV	0C5E	IOINT
FF3F	IOREST	FF4A	IOSAVE	C010	KBDSTB	FD1B	KEYIN
38	KSW	0E3D	LASTPG	0E9A	LOOP1	0C06	LSTFLG
0C01	MSHOTS	?0DEB	NEWADD	0E56	NEXTPG	1032	NTAGN
0FBE	NXTSHT	0D52	OKACK1	0DE4	OKACK2	0C07	OPCDE
E0	OPCHI	50	OPCLO	07D0	PAKLEN	0DC2	PAKOT1
0DBD	PAKOUT	0FD6	PDONE	33	PRDONE	0FE9	PRINT
0FEB	PRINT1	FD	PRTADD	0C0A	RCSUM	FD0C	RDKEY
0C00	REPNUM	0FCA	RPLOOP	0C0C	SAVADD	0C0E	SAVSUM
0E42	SENDIT	0E26	SENDPG	0DA1	SETFLG	FE80	SETINV
FE84	SETNRM	0E52	SKDBL	0C74	SKUPRC	0FC8	SKUPTS
0E95	SKUPXC	C0C0	SLPIO	C0C4	SLPRST	0D1E	SNDACK
0E99	SNDBYT	?0E7E	SNDCHK	0D53	SNDDAT	0E5C	SNDFRM
0E46	SNDIT1	0E0C	SNDPK2	0D33	SNDPK1	0D27	SNDPRD
9800	STADDH	9000	STADDL	0C10	STATE	0C8[illegible]	STPAK
0C8C	STPAK1	8[illegible]	STX	11D6	TDMSG	10EA	TDPRT
1185	TGMSG1	119F	TGMSG2	11C3	TKPMSG	10D0	TKPPRT
FF	TLBTCT	103A	TRGPRT	C0C1	TRIG	0F0A	TRIG1
1172	TRYAGN	0C12	TSHOT	0E8[illegible]	UPDTCK	0CA5	VERCHK
?0CAB	VERIFY	FC22	VTAB	FCA8	WAIT	0C5B	WLOOP
0C14	XCSUM	C0A1	XRDR				

III.2 FZZ

```
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      C ***********************************
      C *
      C *      SODIUM LIDAR PROGRAM
      C *           11/16/82
      C *           D.VOELZ
      C *
      C ***********************************
      C  THIS PROGRAM ( ALONG WITH ITS ASSOCIATED SUBROUTINES )
      C  IS DESIGNED TO CONTROL THE SODIUM LIDAR EXPERIMENT
      C  AT THE UNIVERSITY OF ILLINOIS.
      C  THE PROGRAM DISPLAYS A MAIN MENU. CHOOSING ONE OF THE
      C  OPTIONS DISPLAYED CAUSES THE PROGRAM TO GO TO ONE OF
      C  THE ASSOCIATED SUBROUTINES.
      C
      C  MAIN SUBROUTINES CALLED IN THE PROGRAM FOLLOW:
      C   EXPPAR - EXPERIMENT PARAMETERS
      C   CSTTUS - CURRENT STATUS
      C   LAALN - LOW-ALTITUDE ALIGNMENT ROUTINE
      C   ALNRTN - SODIUM ALIGNMENT ROUTINE
      C   DATRUN - DATA RUN
      C   EXMPRF - EXAMINE PROFILE ON DISK
      C   MOUT - HEX DUMP OF THE ARRAY LDATA
      C
      C  OTHER SUBROUTINES USED:
      C   CLRSCN - CLEAR TERMINAL SCREEN
      C   BAKSCN - NORMAL (BACKGROUND) SCREEN
      C   FORSCN - HIGHLIGHT (FOREGROUND) SCREEN
      C   DATE - GET PRESENT DATE
      C   TIME - GET PRESENT TIME
      C
      C  A DESCRIPTION OF SOME OF THE VARIABLES USED IN THIS PROGRAM
      C  AND ITS SUBROUTINES FOLLOWS:
      C   BINS - # BINS OF INTEREST       BSAT - BASE ALTITUDE (KM)
      C   BSATF - BASE ALTITUDE (FT)      B30 - 30 KM BIN POINTER
      C   B60 - 60 KM BIN POINTER         C - SPEED OF LIGHT
      C   CLA - COLUMN ABUN'D RATIO       CPROF - CURRENT PROFILE
      C   CSET - CURRENT SET              EANG - ELEVATION ANGLE (DEGREES)
      C   FNAME - FILE NAME ARRAY         GATTIM - RECEIVER GATE TIME
      C   HBI - HI BIN OF INTEREST        HDRB - # HEADER BYTES IN DATA FILE
      C   HRI - HI RANGE OF INTEREST      IDATE - DATE ARRAY
      C   INTSIZ - FILE BLOCK SIZE        ITIME - TIME ARRAY
      C   K60 - PHOTONS 60-80 KM          K80 - PHOTONS 80-100 KM
      C   K100 - PHOTONS 100-120 KM       LBI - LO BIN OF INTEREST
      C   LDATA - DATA ARRAY              LRI - LO RANGE OF INTEREST
      C   LREP - DATRUN REP RATE          LSET - PREVIOUS SET #
      C   MSHOTS - SHOTS/PROF (SENT)      PDEL - INTER-PROFILE DELAY
      C   REANG - ELEVA'N ANGLE (RAD)     RECSIZ - FILE RECORD SIZE
      C   REPNUM - REP NUMBER             REPR3 - LAALN REP RATE
      C   REPR4 - ALNRTN REP RATE         RG - RANGE GATE (BIN SIZE)
      C   SETS - # OF SETS                SGP - SIGNAL PHOTONS
      C   SHOTSP - DATRUN SHOTS/PROF      SHOTS3 - LAALN SHOTS/PROF
      C   SHOTS4 - ALNRTN SHOTS/PROF      S20 - # BINS IN 20 KM
      C   TSGP - TOTAL SIGNAL PHOTONS
      C
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OF POOR QUALITY


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      C
      C  FLAGS:
      C   ERRFLG - SET WHEN A LSI11-APPLE TRANSMISSION ERROR OCCURS
      C   DFLAG - SET WHEN A COMPLETED PROFILE IS RECEIVED
      C   RUNFLG - DESIGNATES WHICH SUBROUTINE (LAALN,ALRTN,DATRUN) IS
      C          BEING RUN
      C
0001        INTEGER SETS,PROFS,SHOTSP,CSET,CPROF,LSET,LPROF,HBI,LBI
           >,SHOTS3,SHOTS4,INTSIZ,RECSIZ,B30,B60,S20,K30,K60,K80,K100
           >,SGP,TSGP,PDEL
0002        REAL LREP,LRI,HRI,EANG,BSAT,REPR3,REPR4,PI,C,GATTIM,RG
           >,CLA,REANG,BSATF
0003        LOGICAL*1 IDATE(9),ITIME(8)
0004        BYTE FNAME(15)
      C
0005        COMMON /DATTIM/ IDATE,ITIME
0006        COMMON /SETS/ SETS,PROFS,SHOTSP
0007        COMMON /LREPS/ LREP,LRI,HRI,LBI,HBI,BSAT,BSATF,EANG
           >,REANG,PDEL
0008        COMMON /STATS/ CSET,CPROF,LSET,LPROF
0009        COMMON /CALCS/ K30,K60,K80,K100,SGP,TSGP,CLA
0010        COMMON /ALN/ REPR4,SHOTS4
0011        COMMON /LAAN/REPR3,SHOTS3
0012        COMMON /DISK/ INTSIZ,RECSIZ,FNAME
0013        COMMON/PTERS/ B30,B60,S20
0014        COMMON /CONST/ PI,C,GATTIM,RG
      C
      C  VARIABLE DEFAULT VALUES
      C
0015        SETS = 20
0016        PROFS = 10
0017        SHOTSP = 100
0018        LREP = 10.0
0019        PDEL=0
0020        EANG = 90.
0021        LRI = 0.075
0022        HRI = 149.925
0023        BSAT = 0.
0024        BSATF = 0.
0025        LBI = 1
0026        HBI = 1000
0027        CSET = 1
0028        CPROF = 1
0029        LSET = 0
0030        LPROF = 0
0031        K30 = 0
0032        K60 = 0
0033        K80 = 0
0034        K100 = 0
0035        SGP = 0
0036        TSGP = 0
0037        CLA = 0.
0038        REPR3=10.
0039        SHOTS3=100
```

```
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        REPR4=10.
        SHOTS4=100
        PI=3.1415927
        C=3.0E5
        GATTIM=1.0E-6
        RG=(GATTIM*C)/2.
        REANG=PI/2.
        DATA FNAME/'D','Y','0',':','S','E','T',0,0,0,'.','D','A'
       >,'T',0/
C---------------------------------------------
C  INITIALIZATION
C---------------------------------------------
C  INIT SERIAL RECEIVER INTERRUPT ROUTINE
        CALL INITR
C  SET JOB STATUS FOR TERMINAL CONTINUE MODE
        CALL IPOKE("44,"100.OR.IPEEK("44))
C---------------------------------------------
C  DISPLAY MAIN MENU
C---------------------------------------------
      3 CALL CLRSCN
        CALL BAKSCN
        TYPE 5
        CALL DATE(IDATE)
        CALL TIME(ITIME)
        TYPE 12,(IDATE(I),I=1,9),(ITIME(J),J=1,8)
        TYPE 10
        TYPE 15
        TYPE 20
        TYPE 22
        TYPE 25
        TYPE 30
        TYPE 32
        TYPE 35
      5 FORMAT(' 'T22'SODIUM LIDAR - UNIVERSITY OF ILLINOIS'/)
     10 FORMAT(' 'T35'MAIN MENU'/)
     12 FORMAT(' ',T35,9A1,/T35,8A1,//)
     15 FORMAT('0'T14'<1>  Experiment Parameters'/)
     20 FORMAT(' 'T14'<2>  Current Status'/)
     22 FORMAT(' 'T14'<3>  Low Altitude Alignment Run'/)
     25 FORMAT(' 'T14'<4>  Sodium Alignment Run'/)
     30 FORMAT(' 'T14'<5>  Data Run'/)
     32 FORMAT(' 'T14'<6>  Examine Profile on Disk'/)
     35 FORMAT('0'/T5'Enter an option: '$)
C---------------------------------------------
C  GET AND CHECK RESPONSE
C---------------------------------------------
        READ(5,*,ERR=3) OPT
C  EXPERIMENT PARAMETERS
        IF(OPT.EQ.1) CALL EXPPAR
C  CURRENT STATUS
        IF(OPT.EQ.2) CALL CSTTUS
C  LOW-ALTITUDE ALIGNMENT RUN
        IF(OPT.EQ.3) CALL LAALN
C  SODIUM ALIGNMENT RUN
```

```
            IF(OPT.EQ.4) CALL ALNRTN
      C  DATA RUN
            IF(OPT.EQ.5) CALL DATRUN
      C  EXAMINE PROFILE ON DISK
            IF(OPT.EQ.6) CALL EXMPRF
      C  HEX DUMP OF ARRAY LDATA
            IF(OPT.EQ.7) CALL MOUT
            GOTO 3
            STOP
            END
```

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```
FORTRAN IV      Storage Map for Program Unit .MAIN.

Local Variables, .PSECT $DATA, Size = 000020 (    8. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
I       I*2   000006      J       I*2   000010      OPT     R*4   000012

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
IDATE   L*1   000000      ITIME   L*1   000011

COMMON Block /SETS  /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
SETS    I*2   000000      PROFS   I*2   000002      SHOTSP  I*2   000004

COMMON Block /LREPS /, Size = 000042 (   17. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
LREP    R*4   000000      LRI     R*4   000004      HRI     R*4   000010
LBI     I*2   000014      HBI     I*2   000016      BSAT    R*4   000020
BSATF   R*4   000024      EANG    R*4   000030      REANG   R*4   000034
PDEL    I*2   000040

COMMON Block /STATS /, Size = 000010 (    4. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
CSET    I*2   000000      CPROF   I*2   000002      LSET    I*2   000004
LPROF   I*2   000006

COMMON Block /CALCS /, Size = 000020 (    8. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
K30     I*2   000000      K60     I*2   000002      K80     I*2   000004
K100    I*2   000006      SGP     I*2   000010      TSGP    I*2   000012
CLA     R*4   000014

COMMON Block /ALN   /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
.EPR4   R*4   000000      SHOTS4  I*2   000004

COMMON Block /LAAN  /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
REPR3   R*4   000000      SHOTS3  I*2   000004

COMMON Block /DISK  /, Size = 000023 (   10. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
INTSIZ  I*2   000000      RECSIZ  I*2   000002      FNAME   L*1   000004
```

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```
FORTRAN IV      Storage Map for Program Unit .MAIN.

COMMON Block /PTERS /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
B30     I*2   000000      B60     I*2   000002      S20     I*2   000004

COMMON Block /CONST /, Size = 000020 (    8. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
PI      R*4   000000      C       R*4   000004      GATTIM  R*4   000010
RG      R*4   000014

Local and COMMON Arrays:

Name      Type      Section  Offset  ------Size----- Dimensions
FNAME   L*1       DISK     000004  000017 (    8.) (15)
IDATE   L*1       DATTIM   000000  000011 (    5.) (9)
ITIME   L*1       DATTIM   000011  000010 (    4.) (8)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type    Name    Type    Name    Type    Name    Type    Name    Type
ALNRTN  R*4     BAKSCN  R*4     CLRSCN  R*4     CSTTUS  R*4     DATE    R*4
DATRUN  R*4     EXMPRF  R*4     EXPPAR  R*4     INITR   I*2     IPEEK   I*2
IPOKE   I*2     LAALN   I*2     MOUT    I*2     TIME    R*4
```

III.3 EXPPAR

```
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      C ****************************************************
      C
      C  SUBROUTINE EXPPAR - EXPERIMENT PARAMETERS
      C                      D.VOELZ
      C
      C ****************************************************
      C  THIS SUBROUTINE DISPLAYS THE LIDAR EXPERIMENT
      C  PARAMETER VALUES AND ALLOWS THE VALUES TO BE
      C  CHANGED.
      C
            SUBROUTINE EXPPAR
            INTEGER SETS,PROFS,SHOTSP,LBI,HBI,PDEL
            REAL LREP,LRI,HRI,EANG,C,GATTIM,RG,PI,REANG,BSAT,DENOM
            REAL BSATF
            LOGICAL*1 IDATE(9),ITIME(8)
            BYTE CHNG
      C
            COMMON /DATTIM/ IDATE,ITIME
            COMMON /SETS/ SETS,PROFS,SHOTSP
            COMMON /LREPS/ LREP,LRI,HRI,LBI,HBI,BSAT,BSATF,EANG,
           >REANG,PDEL
            COMMON /CONST/ PI,C,GATTIM,RG
      C
      C---------------------------------------
      C  DISPLAY PARAMETER MENU
      C---------------------------------------
      C  CLEAR SCREEN AND SET ON BACKGORUND (LO INTENSITY)
          5 CALL CLRSCN
            CALL BAKSCN
      C GET DATE AND TIME
            CALL DATE(IDATE)
            CALL TIME(ITIME)
            TYPE 20,(IDATE(I),I=1,9),(ITIME(J),J=1,8)
      C SET SCREEN ON FOREGROUND (HI INTENSITY)
            CALL FORSCN
            TYPE 30,SETS
            TYPE 35,PROFS
            TYPE 40,SHOTSP
            TYPE 45,LREP
            TYPE 46,PDEL
            TYPE 47,EANG
            TYPE 48,BSAT
            TYPE 49,BSATF
            TYPE 50,LRI,HRI
            TYPE 52,LBI,HBI
      C SET SCREEN ON BACKGROUND (LO INTENSITY)
            CALL BAKSCN
            TYPE 70
         20 FORMAT(' ',/,T29,'EXPERIMENT PARAMETERS',/,/T35,9A1,/T35,8A1,//)
         30 FORMAT(' ',T14,'<S>  #Sets ',21X,'= ',I4,'                ')
         35 FORMAT(' ',T14,'<P>  #Profiles Per Set ',9X,'= ',I4
           >,'                ')
         40 FORMAT(' ',T14,'<L>  #Laser Shots Per Profile',3X,'= ',I4
           >,'                ')
```

```
      45 FORMAT(' ',T14,'<R>  Laser Rep Rate',13X,'=    ',F4.1,' Hz'
     >,'                ')
      46 FORMAT(' ',T14,'<D>  Inter-Profile Delay',8x,'= ',I4,' Sec'
     >,'              ')
      47 FORMAT(' ',T14,'<E>  Elevation Angle',12X,'=  ',F5.1,' Degrees'
     >,'          ')
      48 FORMAT(' ',T14,'<B>  Base Altitude',14X,'=  ',F6.2,' KM'
     >,'              ')
      49 FORMAT(' ',T14,'<F>',29X,'=  ',F7.1,' Ft',,'            ')
      50 FORMAT(' ',T14,'<H>  Altitude Range of Data',4X,' =  ',F6.2,
     +'  To ',F7.2,' KM')
      52 FORMAT(' ',T14,'<N>  Range Bins',16X,' =    ',I4,'  To ',I4
     >,'          ')
      70 FORMAT('0',///,T5,'To change any parameter value first enter th
     +e corresponding',/T5,'LETTER and then RETURN  ',$)
C-------------------------------------------
C  GET RESPONSE
C-------------------------------------------
         READ(5,80,ERR=5) CHNG
   80 FORMAT(A1)
C-------------------------------------------
C  CHECK RESPONSE AND CHANGE VALUES
C-------------------------------------------
         CALL FORSCN
C  CHANGE SETS
   81  IF(CHNG.NE.'S') GOTO 90
         TYPE 85
   85    FORMAT('0',T14,'#Sets = ',$)
          READ(5,*,ERR=200)SETS
           IF(SETS.LE.0) GOTO 200
          GOTO 5
C  CHANGE PROFILES PER SET
   90  IF(CHNG.NE.'P') GOTO 100
   92    TYPE 93
   93    FORMAT('0',T14,'#Profiles Per Set = ',$)
          READ(5,*,ERR=200)PROFS
           IF(PROFS.LE.0) GOTO 200
          GOTO 5
C  CHANGE LASER SHOTS PER PROFILE
  100  IF(CHNG.NE.'L') GOTO 110
  102    TYPE 103
  103    FORMAT('0',T14,'#Laser Shots Per Profile = ',$)
          READ(5,*,ERR=200)SHOTSP
           IF(SHOTSP.LE.0)GOTO 200
          GOTO 5
C  CHANGE LASER REP RATE
  110  IF(CHNG.NE.'R') GOTO 115
  112    TYPE 113
  113    FORMAT('0',T14,'Laser Rep Rate = ',$)
          READ(5,*,ERR=200)LREP
           IF((LREP.LE.0.0).OR.(LREP.GT.10.0)) GOTO 200
          GOTO 5
C  CHANGE INTER-PROFILE DELAY
  115  IF(CHNG.NE.'D')GOTO 120
```

```
  117   TYPE 113
  118   FORMAT('0',T14,'Inter-Profile Delay = ',$)
          READ(5,*,ERR=200) PDEL
           IF(PDEL.LT.0)GOTO 200
          GOTO 5
C  CHANGE ELEVATION ANGLE
  120  IF(CHNG.NE.'E')GOTO 130
  122   TYPE 123
  123   FORMAT('0',T14,'Elevation Angle = ',$)
          READ(5,*,ERR=200)EANG
           IF((EANG.LE.0).OR.(EANG.GT.90)) GOTO 200
           REANG=(PI/180.)*EANG
        GOTO 300
C  CHANGE BASE ALTITUDE
  130 IF(CHNG.NE.'B')GOTO 140
  132  TYPE 133
  133  FORMAT('0',T14,'Base Altitude (KM) = ',$)
         READ(5,*,ERR=200)BSAT
         BSATF=3281.*BSAT
        GOTO 300
  140 IF(CHNG.NE.'F')GOTO 150
  142  TYPE 143
  143  FORMAT('0',T14,'Base Altitude (Feet)= ',$)
         READ(5,*,ERR=200)BSATF
         BSAT=.0003048*BSATF
        GOTO 300
C  CHANGE ALTITUDE RANGE OF DATA
  150  IF(CHNG.NE.'H') GOTO 160
  152   TYPE 153
  153   FORMAT('0',T14,'Altitude Range of Data = ',$)
          READ(5,*,ERR=200)LRI
           IF(LRI.LT.BSAT) GOTO 200
         TYPE 157
  157   FORMAT('+',T34,'To   ',$)
          READ(5,*,ERR=200)HRI
           IF(HRI.LE.LRI) GOTO 200
        GOTO 290
C  CHANGE RANGE BINS
  160 IF(CHNG.NE.'N') RETURN
  162   TYPE 163
  163   FORMAT('0',T14,'Range Bins = ',$)
          READ(5,*,ERR=200)LBI
         TYPE 167
  167   FORMAT('+',T22,'To   ',$)
          READ(5,*,ERR=200)HBI
           IF(HBI.LE.LBI) GOTO 200
        REANG=(PI/180.)*EANG
        GOTO 295
C-------------------------------------
C  ERROR MESSAGES
C-------------------------------------
  200 TYPE 210
  210 FORMAT(' ',T7,'?? PARAMETER RANGE ERROR')
        GOTO 81
```

```
C----------------------------------------
C  RANGE CALCULATIONS
C----------------------------------------
  290 REANG=(PI/180.)*EANG
      DENOM=SIN(REANG)*RG
      LBI=IFIX((LRI+(RG/2.)-BSAT)/DENOM)
      HBI=IFIX((HRI+(1.5*RG)-BSAT)/DENOM)
  295  IF(HBI.GT.2000)HBI=2000
       IF(LBI.LT.1)LBI=1
  300   LRI=FLOAT(((LBI*RG)-(RG/2.))*SIN(REANG)+BSAT)
        HRI=FLOAT(((HBI*RG)-(RG/2.))*SIN(REANG)+BSAT)
      GOTO 5
C
      STOP
      END
```

```
FORTRAN IV      Storage Map for Program Unit EXPPAR

Local Variables, .PSECT $DATA, Size = 000040 (   16. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
CHNG   L*1   000012      DENOM  R*4   000006      I      I*2   000014
J      I*2   000016

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
IDATE  L*1   000000      ITIME  L*1   000011

COMMON Block /SETS  /, Size = 000006 (    3. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
SETS   I*2   000000      PROFS  I*2   000002      SHOTSP I*2   000004

COMMON Block /LREPS /, Size = 000042 (   17. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
LREP   R*4   000000      LRI    R*4   000004      HRI    R*4   000010
LBI    I*2   000014      HBI    I*2   000016      BSAT   R*4   000020
BSATF  R*4   000024      EANG   R*4   000030      REANG  R*4   000034
PDEL   I*2   000040

COMMON Block /CONST /, Size = 000020 (    8. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
PI     R*4   000000      C      R*4   000004      GATTIM R*4   000010
RG     R*4   000014

Local and COMMON Arrays:

Name     Type    Section Offset   ------Size----- Dimensions
IDATE  L*1       DATTIM  000000   000011 (    5.) (9)
ITIME  L*1       DATTIM  000011   000010 (    4.) (8)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type    Name    Type    Name    Type    Name    Type    Name    Type
BAKSCN  R*4     CLRSCN  R*4     DATE    R*4     FLOAT   R*4     FORSCN  R*4
IFIX    I*2     SIN     R*4     TIME    R*4
```

III.4 CSTTUS

```
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      C ***************************************************
      C
      C       SUBROUTINE CSTTUS - CURRENT STATUS
      C                   D.VOELZ
      C
      C ***************************************************
      C
      C
      C   THIS SUBROUTINE DISPLAYS THE CURRENT STATUS OF THE EXPERIMENT.
      C   ALSO DISPLAYED ARE THE CHARACTERISTIC DATA VALUES FOR THE LAST
      C   RECORDED PROFILE.  THE SUBROUTINE ALLOWS THE VALUES OF THE
      C   CURRENT SCAN AND PROFILE TO BE CHANGED.
      C
0001        SUBROUTINE CSTTUS
0002        INTEGER SETS,PROFS,SHOTSP,CSET,CPROF,LSET,LPROF,CHNG
           >,K30,K60,K80,K100,SGP,TSGP
0003        REAL EANG,CLA
0004        LOGICAL*1 IDATE(9),ITIME(8)
      C
0005        COMMON /DATTIM/ IDATE,ITIME
0006        COMMON /SETS/ SETS,PROFS,SHOTSP
0007        COMMON /STATS/ CSET,CPROF,LSET,LPROF
0008        COMMON /CALCS/ K30,K60,K80,K100,SGP,TSGP,CLA
      C
      C   ------------------------------------------------------
      C   DISPLAY CURRENT STATUS MENU
      C   ------------------------------------------------------
0009      5  CALL CLRSCN
0010         CALL BAKSCN
0011        TYPE 30
0012         CALL DATE(IDATE)
0013        TYPE 35,(IDATE(I),I=1,9),SETS
0014         CALL TIME(ITIME)
0015        TYPE 40,(ITIME(J),J=1,8)
0016         CALL FORSCN
0017        TYPE 45,CSET
0018         CALL BAKSCN
0019        TYPE 50,PROFS
0020         CALL FORSCN
0021        TYPE 55,CPROF
0022         CALL BAKSCN
0023        TYPE 60
0024        TYPE 65,LSET,SHOTSP
0025        TYPE 70,LPROF
0026        TYPE 75,K30,K60,K80,K100
0027        TYPE 95,TSGP
0028        TYPE 100,SGP
0029        TYPE 105,CLA
0030        TYPE 110
      C
0031     30 FORMAT('+',T2,'CURRENT STATUS  ---------------------------------
           +---------------')
0032     35 FORMAT('0',T5,9A1,21X,'Desired # Sets ',11X,'=',I6)
0033     40 FORMAT(' ',T5,8A1,$)
```

```
   45 FORMAT('+',T20,'<CS>  Current Set ',12X,'=',I6)
   50 FORMAT(' ',T35,'Profiles Per Set ',9X,'=',I6)
   55 FORMAT(' ',T31,'<CP>  Current Profile',9X,'=',I6)
   60 FORMAT('0',T2,'LAST RECORDED PROFILE  ---------------------------
     +------------------')
   65 FORMAT('0',T5,'Set #      ',I4,16X,'Laser Shots Per Profile   ='
     +,I6)
   70 FORMAT(' ',T5,'Profile # ',I4,16X,'Detected Photons:')
   75 FORMAT(' ',T50,'at 30 Km',3X,'=',I6,/T47,'60 -  80 Km',3X,
     +'=',I6,/T47,'80 - 100 Km',3X,'=',I6,/T46,'100 - 120 Km',3X,
     +'=',I6)
   95 FORMAT(' ',T35,'Total Signal Photons       =',I6)
  100 FORMAT(' ',T35,'Signal Photons Per Shot    =',I6)
  105 FORMAT(' ',T35,'Column Abundance Ratio     =',F6.2)
  110 FORMAT('0',T2,'To change the Current Set or Profile values first
     + enter the',/T2,'corresponding LETTERS then RETURN  ',$)
C  ----------------------------------------------------------
C  GET RESPONSE
C  ----------------------------------------------------------
      READ(5,150,ERR=5) CHNG
  150 FORMAT(A2)
C  ----------------------------------------------------------
C  CHECK RESPONSE AND CHANGE VALUES
C  ----------------------------------------------------------
      CALL FORSCN
C  CHANGE CURRENT SET
  155 IF(CHNG.NE.'CS') GOTO 170
  160  TYPE 162
  162  FORMAT('0',T14,'Current Set =  ',$)
        READ(5,*,ERR=200)CSET
        IF(CSET.LE.0)GOTO 200
       GOTO 5
C  CHANGE CURRENT PROFILE
  170 IF(CHNG.NE.'CP')RETURN
  172 TYPE 173
  173 FORMAT('0',T14,'Current Profile =  ',$)
      READ(5,*,ERR=200) CPROF
      IF(CPROF.LE.0.OR.CPROF.GT.PROFS)GOTO 200
      GOTO 5
C  ----------------------------------------------------------
C  ERROR MESSAGES
C  ----------------------------------------------------------
  200 TYPE 210
  210 FORMAT(' ',T7,'?? PARAMETER RANGE ERROR')
      GOTO 155
      STOP
      END
```

```
FORTRAN IV      Storage Map for Program Unit CSTTUS

Local Variables, .PSECT $DATA, Size = 000020 (    8. words)

Name    Type   Offset       Name    Type   Offset       Name    Type   Offset
CHNG    I*2    000006       EANG    R*4    000010       I       I*2    000014
J       I*2    000016

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name    Type   Offset       Name    Type   Offset       Name    Type   Offset
IDATE   L*1    000000       ITIME   L*1    000011

COMMON Block /SETS  /, Size = 000006 (    3. words)

Name    Type   Offset       Name    Type   Offset       Name    Type   Offset
SETS    I*2    000000       PROFS   I*2    000002       SHOTSP  I*2    000004

COMMON Block /STATS /, Size = 000010 (    4. words)

Name    Type   Offset       Name    Type   Offset       Name    Type   Offset
CSET    I*2    000000       CPROF   I*2    000002       LSET    I*2    000004
LPROF   I*2    000006

COMMON Block /CALCS /, Size = 000020 (    8. words)

Name    Type   Offset       Name    Type   Offset       Name    Type   Offset
K30     I*2    000000       K60     I*2    000002       K80     I*2    000004
K100    I*2    000006       SGP     I*2    000010       TSGP    I*2    000012
CLA     R*4    000014

Local and COMMON Arrays:

Name     Type    Section Offset   ------Size----- Dimensions
IDATE   L*1      DATTIM  000000   000011 (    5.) (9)
ITIME   L*1      DATTIM  000011   000010 (    4.) (8)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type   Name    Type   Name    Type   Name    Type   Name    Type
BAKSCN  R*4    CLRSCN  R*4    DATE    R*4    FORSCN  R*4    TIME    R*4
```

III.5 LAALN

```
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      C ****************************************
      C
      C  SUBROUTINE LAALN.FOR - LOW ALTITUDE ALIGNMENT ROUTINE
      C                    D.VOELZ
      C
      C ****************************************
      C
      C  THIS SUBROUTINE INITIATES A LOW ALTITUDE ALIGNMENT DATA
      C  RUN.
      C
0001        SUBROUTINE LAALN
0002        REAL REPR3
0003        INTEGER SHOTS3,MSHOTS,REPNUM,BCNT,BNMBR,LDATA(2100)
0004        LOGICAL*1 IDATE(9),ITIME(8)
0005        BYTE RUNFLG,DFLAG,ERRFLG,MON,JCHAR,OPT
      C
0006        COMMON/DATTIM/ IDATE,ITIME
0007        COMMON/LAAN/ REPR3,SHOTS3
0008        COMMON/FLAGS/ RUNFLG,DFLAG,ERRFLG
0009        COMMON/SEND/ REPNUM,MSHOTS
0010        COMMON/BUFF/ LDATA
      C
      C  TYPE LOW ALTITUDE ALIGNMENT ROUTINE SCREEN
      C
0011      5 CALL CLRSCN
0012        CALL BAKSCN
0013        CALL DATE(IDATE)
0014        CALL TIME(ITIME)
0015        TYPE 20,(IDATE(I),I=1,9),(ITIME(J),J=1,8)
0016        CALL FORSCN
0017        TYPE 22,SHOTS3
0018        TYPE 24,REPR3
0019        CALL BAKSCN
0020        TYPE 26
0021        TYPE 30
0022     20 FORMAT(' ',/,T25,'LOW ALTITUDE ALIGNMENT ROUTINE',/,/T35
           >,9A1,/T35,8A1,//)
0023     22 FORMAT(' ',T10,'<L>  Laser Shots Per Profile  = ',I4
           >,'     ')
0024     24 FORMAT(' ',T10,'<R>  Laser Rep Rate           = ',F4.1
           +,' Hz','    ')
0025     26 FORMAT(' ',//,T5,'To change any parameter value enter the corres
           +ponding LETTER',/T5,'and then RETURN')
0026     30 FORMAT(' ',//,T5,'To begin the alignment routine press "Y"
           + then RETURN   ',$)
      C ======================================
      C  GET & CHECK RESPONSE
      C ======================================
0027        READ(5,80,ERR=5) OPT
0028     80 FORMAT(A1)
      C
0029        CALL FORSCN
      C  CHANGE LASER SHOTS PER PROFILE
0030     81 IF(OPT.NE.'L') GOTO 90
```

```
          TYPE 85
      85 FORMAT('0',T10,'Laser Shots Per Profile = ',$)
           READ(5,*,ERR=200)SHOTS3
             IF(SHOTS3.LE.0)GOTO 200
           GOTO 5
    C  CHANGE LASER REP RATE
      90 IF(OPT.NE.'R') GOTO 100
          TYPE 95
      95 FORMAT('0',T10,'Laser Rep Rate = ',$)
           READ(5,*,ERR=200)REPR3
             IF((REPR3.LE.0.0).OR.(REPR3.GT.10.0)) GOTO 200
           GOTO 5
    C ========================================
    C  LOW ALTITUDE ALIGNMENT RUN
    C ========================================
     100 IF(OPT.NE.'Y') RETURN
          CALL BAKSCN
    C
    C  PARAMETER CALCULATIONS
    C
          MSHOTS=SHOTS3
          REPNUM=IFIX((SQRT((1.02046*1.E6/REPR3-57251.)*4./15.+
         >(5.4*5.4))-5.4)/2.+.5)
    C
    C  INIT FLAGS & START PROFILE RUN
    C
     120 DFLAG=0
          ERRFLG=0
          CALL SNDCOM
    C
    C  GET DATE AND TIME
    C
          CALL TIME(ITIME)
          CALL DATE(IDATE)
    C
    C  WAIT FOR PROFILE
    C
     130 ICHAR=ITTINR()
          JCHAR=ICHAR
          IF(JCHAR.EQ.'S') GOTO 180
          IF(DFLAG.NE.1)GOTO 130
          IF(ERRFLG.EQ.1)GOTO 180
    C
    C  DISPLAY
    C
          DO 160 K=1,3
          TYPE 135,(IDATE(I),I=1,9),K,(ITIME(I),I=1,8)
     135 FORMAT(' ',T5,9A1,25X,I2,/T5,8A1)
          BCNT=1+200*(K-1)
            DO 150 J=1,20
            BNMBR=BCNT+10*(J-1)
            TYPE 140,BNMBR,(LDATA(I),I=BNMBR,BNMBR+9)
     140    FORMAT(' ',I5,'-',10I6)
     150    CONTINUE
```

```
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0073            PAUSE
0074        160 CONTINUE
0075        163 TYPE 165
0076        165 FORMAT(' ',//,T19,'Do you want to run the Routine
              > again ? ',$)
0077            READ(5,170,ERR=163)MON
0078        170 FORMAT(A1)
0079            IF(MON.EQ.'Y')GOTO 120
          C
0081        180 RETURN
          C
          C----------------------------------------
          C  ERROR MESSAGES
          C----------------------------------------
0082        200 TYPE 210
0083        210 FORMAT(' ',T7,'?? PARAMETER RANGE ERROR')
0084            GOTO 81
          C
0085            STOP
0086            END
```

```
FORTRAN IV      Storage Map for Program Unit LAALN

Local Variables, .PSECT $DATA, Size = 000046 (   19. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
BCNT    I*2   000014      BNMBR   I*2   000016      I       I*2   000024
ICHAR   I*2   000030      J       I*2   000026      JCHAR   L*1   000021
K       I*2   000032      MON     L*1   000020      OPT     L*1   000022

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
IDATE   L*1   000000      ITIME   L*1   000011

COMMON Block /LAAN  /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
REPR3   R*4   000000      SHOTS3  I*2   000004

COMMON Block /FLAGS /, Size = 000003 (    2. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
RUNFLG  L*1   000000      DFLAG   L*1   000001      ERRFLG  L*1   000002

COMMON Block /SEND  /, Size = 000004 (    2. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
REPNUM  I*2   000000      MSHOTS  I*2   000002

COMMON Block /BUFF  /, Size = 010150 ( 2100. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
LDATA   I*2   000000

Local and COMMON Arrays:

Name       Type    Section Offset  ------Size----- Dimensions
IDATE   L*1        DATTIM  000000  000011 (    5.) (9)
ITIME   L*1        DATTIM  000011  000010 (    4.) (8)
LDATA   I*2        BUFF    000000  010150 ( 2100.) (2100)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type   Name    Type   Name    Type   Name    Type   Name    Type
BAKSCN  R*4    CLRSCN  R*4    DATE    R*4    FORSCN  R*4    IFIX    I*2
ITTINR  I*2    SNDCOM  R*4    SQRT    R*4    TIME    R*4
```

III.6 ALNRTN

```
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      C ****************************************
      C
      C  SUBROUTINE ALNRTN.FOR - SODIUM ALIGNMENT ROUTINE
      C                     D.VOELZ
      C
      C ****************************************
      C
      C  THIS SUBROUTINE INITIATES A SODIUM ALIGNMENT DATA
      C  RUN.
      C
0001        SUBROUTINE ALNRTN
0002        REAL REPR4,LREP,LRI,HRI,BSAT,EANG,PI,C,GATTIM,RG,REANG
           >,DENOM,BSATF
0003        INTEGER REPNUM,SHOTS4,MSHOTS,LBI,HBI,INTSIZ,RECSIZ,B30
           >,B60,S20,PDEL
0004        LOGICAL*1 IDATE(9),ITIME(8)
0005        BYTE RUNFLG,DFLAG,ERRFLG,MON,JCHAR,OPT
      C
0006        COMMON/PTERS/ B30,B60,S20
0007        COMMON/LREPS/ LREP,LRI,HRI,LBI,HBI,BSAT,BSATF,EANG,
           >REANG,PDEL
0008        COMMON/DATTIM/ IDATE,ITIME
0009        COMMON/ALN/ REPR4,SHOTS4
0010        COMMON/FLAGS/ RUNFLG,DFLAG,ERRFLG
0011        COMMON/SEND/ REPNUM,MSHOTS
0012        COMMON/CONST/ PI,C,GATTIM,RG
      C
      C  TYPE SODIUM ALIGNMENT ROUTINE SCREEN
      C
0013      5 CALL CLRSCN
0014        CALL BAKSCN
0015        CALL DATE(IDATE)
0016        CALL TIME(ITIME)
0017        TYPE 20,(IDATE(I),I=1,9),(ITIME(J),J=1,8)
0018        CALL FORSCN
0019        TYPE 22,SHOTS4
0020        TYPE 24,REPR4
0021        CALL BAKSCN
0022        TYPE 26
0023        TYPE 30
0024     20 FORMAT(' ',/,T28,'SODIUM ALIGNMENT ROUTINE',/,/T35,9A1,/T35
           >,8A1,//)
0025     22 FORMAT(' ',T10,'<L>  Laser Shots Per Profile  = ',I4
           >,'    ')
0026     24 FORMAT(' ',T10,'<R>  Laser Rep Rate            = ',F4.1
           +,' Hz','   ')
0027     26 FORMAT(' ',//,T5,'To change any parameter value enter the corres
           +ponding LETTER',/T5,'and then RETURN')
0028     30 FORMAT(' ',//,T5,'To begin the alignment routine press "Y"
           + then RETURN  ',$)
      C ======================================
      C  GET & CHECK RESPONSE
      C ======================================
0029        READ(5,80,ERR=5) OPT
```

```
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0030        80 FORMAT(A1)
          C
0031           CALL FORSCN
          C  CHANGE LASER SHOTS PER PROFILE
0032        81 IF(OPT.NE.'L') GOTO 90
0034           TYPE 85
0035        85 FORMAT('0',T10,'Laser Shots Per Profile = ',$)
0036            READ(5,*,ERR=200)SHOTS4
0037             IF(SHOTS4.LE.0)GOTO 200
0039            GOTO 5
          C  CHANGE LASER REP RATE
0040        90 IF(OPT.NE.'R') GOTO 100
0042           TYPE 95
0043        95 FORMAT('0',T10,'Laser Rep Rate = ',$)
0044            READ(5,*,ERR=200)REPR4
0045             IF((REPR4.LE.0.0).OR.(REPR4.GT.10.0)) GOTO 200
0047            GOTO 5
          C ======================================
          C  SODIUM ALIGNMENT RUN
          C ======================================
0048       100 IF(OPT.NE.'Y') RETURN
0050           CALL BAKSCN
0051           RUNFLG=3
          C
          C  PARAMETER CALCULATIONS
          C
0052           DENOM=SIN(REANG)*RG
0053           B30=IFIX((30.+(RG/2)-BSAT)/DENOM+.5)
0054           B60=IFIX((60.+(RG/2)-BSAT)/DENOM+.5)
0055           S20=IFIX((20.+(RG/2))/DENOM+.5)
0056           MSHOTS=SHOTS4
0057           REPNUM=IFIX((SQRT((1.02046*1.E6/REPR4-57251.)*4./15.+
              >(5.4*5.4))-5.4)/2.+.5)
          C
          C  INIT FLAGS & START PROFILE RUN
          C
0058       120 DFLAG=0
0059           ERRFLG=0
0060           CALL SNDCOM
          C
          C  GET DATE AND TIME
          C
0061           CALL TIME(ITIME)
0062           CALL DATE(IDATE)
          C
          C  WAIT FOR PROFILE
          C
0063       130 ICHAR=ITTINR()
0064           JCHAR=ICHAR
0065           IF(JCHAR.EQ.'S') GOTO 160
0067           IF(DFLAG.NE.1)GOTO 130
0069           IF(ERRFLG.EQ.1)GOTO 160
0071           CALL DISCAL
          C
```

```
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0072      135 TYPE 140
0073      140 FORMAT(' ',//,T19,'Do you want to run the Routine
             > again ? ',$)
0074          READ(5,145,ERR=135)MON
0075      145 FORMAT(A1)
0076          IF(MON.EQ.'Y')GOTO 120
        C
0078      160 RETURN
        C
        C----------------------------------------
        C  ERROR MESSAGES
        C----------------------------------------
0079      200 TYPE 210
0080      210 FORMAT(' ',T7,'?? PARAMETER RANGE ERROR')
0081          GOTO 81
        C
0082          STOP
0083          END
```

```
FORTRAN IV      Storage Map for Program Unit ALNRTN

Local Variables, .PSECT $DATA, Size = 000060 (   24. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
DENOM  R*4   000006     I      I*2   000022     ICHAR  I*2   000026
INTSIZ I*2   000012     J      I*2   000024     JCHAR  L*1   000017
MON    L*1   000016     OPT    L*1   000020     RECSIZ I*2   000014

COMMON Block /PTERS /, Size = 000006 (    3. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
B30    I*2   000000     B60    I*2   000002     S20    I*2   000004

COMMON Block /LREPS /, Size = 000042 (   17. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
LREP   R*4   000000     LRI    R*4   000004     HRI    R*4   000010
LBI    I*2   000014     HBI    I*2   000016     BSAT   R*4   000020
BSATF  R*4   000024     EANG   R*4   000030     REANG  R*4   000034
PDEL   I*2   000040

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
IDATE  L*1   000000     ITIME  L*1   000011

COMMON Block /ALN   /, Size = 000006 (    3. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
REPR4  R*4   000000     SHOTS4 I*2   000004

COMMON Block /FLAGS /, Size = 000003 (    2. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
RUNFLG L*1   000000     DFLAG  L*1   000001     ERRFLG L*1   000002

COMMON Block /SEND  /, Size = 000004 (    2. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
REPNUM I*2   000000     MSHOTS I*2   000002

COMMON Block /CONST /, Size = 000020 (    8. words)

Name   Type  Offset     Name   Type  Offset     Name   Type  Offset
PI     R*4   000000     C      R*4   000004     GATTIM R*4   000010
RG     R*4   000014

Local and COMMON Arrays:

Name     Type    Section Offset  ------Size----- Dimensions
IDATE  L*1       DATTIM  000000  000011 (    5.) (9)
ITIME  L*1       DATTIM  000011  000010 (    4.) (8)
```

FORTRAN IV Storage Map for Program Unit ALNRTN

Subroutines, Functions, Statement and Processor-Defined Functions:

Name	Type	Name	Type	Name	Type	Name	Type	Name	Type
BAKSCN	R*4	CLRSCN	R*4	DATE	R*4	DISCAL	R*4	FORSCN	R*4
IFIX	I*2	ITTINR	I*2	SIN	R*4	SNDCOM	R*4	SQRT	R*4
TIME	R*4								

III.7 DATRUN

```
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      C ***********************************************************
      C
      C    SUBROUTINE DATRUN - DATA RUN
      C              D.VOELZ
      C
      C ***********************************************************
      C
      C  THIS SUBROUTINE INITIATES A DATA RUN (WHICH CONSISTS
      C  OF A SET OF PROFILES).
      C
            SUBROUTINE DATRUN
            LOGICAL*1 IIDATE(9),ITIME(8)
            REAL LREP,LRI,HRI,BSAT,EANG,C,GATTIM,RG,PI,REANG,DENOM,BSATF
            INTEGER SETS,PROFS,SHOTSP,CSET,CPROF,LSET,LPROF,HBI,LBI
           >,INTSIZ,RECSIZ,B30,B60,S20,REPNUM,MSHOTS,MN,DAY,YR,HDRB
           >,BINS,LDATA(2100),PDEL
            INTEGER*4 TIM2,TIML,TIMH,STIM,DTIM
            BYTE OPT,MON,RUNFLG,FNAME(15),EXT(3),DFLAG,ERRFLG
           >,JCHAR
      C
            COMMON /DATTIM/ IIDATE,ITIME
            COMMON /DISK/ INTSIZ,RECSIZ,FNAME
            COMMON /PTERS/ B30,B60,S20
            COMMON /LREPS/ LREP,LRI,HRI,LBI,HBI,BSAT,BSATF,EANG,
           >REANG,PDEL
            COMMON /SETS/ SETS,PROFS,SHOTSP
            COMMON /FLAGS/ RUNFLG,DFLAG,ERRFLG
            COMMON /SEND/ REPNUM,MSHOTS
            COMMON /STATS/ CSET,CPROF,LSET,LPROF
            COMMON/CONST/ PI,C,GATTIM,RG
            COMMON/BUFF/LDATA
      C
            HDRB=9
            BINS=HBI-LBI+1
            RECSIZ=(BINS+HDRB+1)/2
            INTSIZ=IFIX(FLOAT(PROFS)*(BINS+HDRB)/256.+1.1)
      C
      C  TYPE DATA RUN SCREEN
      C
          5 CALL CLRSCN
            CALL DATE(IIDATE)
            CALL TIME(ITIME)
            TYPE 20,(IIDATE(I),I=1,9),(ITIME(J),J=1,8)
            TYPE 25,RECSIZ,INTSIZ
            TYPE 30
         20 FORMAT(' ',/,T35,'DATA RUN',/,/T35,9A1,/T35,8A1,//)
         25 FORMAT(' ',/,T5,'Disk Parameters:',/T8,'Recordsize    = ',I4
           >,/T8,'Set Blocksize = ',I4,/)
         30 FORMAT(' ',//,T5,'To begin a Data Run press "Y" then RETURN  '
           >,$)
      C ======================================
      C  GET & CHECK RESPONSE
      C ======================================
            READ(5,80,ERR=5) OPT
```

```
   80 FORMAT(A1)
      IF(OPT.NE.'Y') RETURN
C =======================================
C  DATA RUN
C =======================================
      RUNFLG=1
C
C  UPDATE SET FILE NAME
C
      ENCODE(3,100,EXT)CSET
  100 FORMAT(I3)
      DO 105 I=1,3
      FNAME(7+I)='0'
  105 IF(EXT(I).NE.' ')FNAME(7+I)=EXT(I)
C
C  PARAMETER CALCULATIONS
C
      CALL JICVT(PDEL,DTIM)
      DTIM=60*DTIM
      DENOM=SIN(REANG)*RG
      B30=IFIX((30.+(RG/2.)-BSAT)/DENOM+.5)
      B60=IFIX((60.+(RG/2.)-BSAT)/DENOM+.5)
      S20=IFIX((20.+(RG/2.))/DENOM+.5)
      MSHOTS=SHOTSP
      REPNUM=IFIX((SQRT((1.02046*1.0E6/LREP-57251.)*4./15.+
     >(5.4*5.4))-5.4)/2.+.5)
C -------------------------------------
C  START DATA RUN
C ---------------------------------------
      LSET=CSET
      PRINT 115,CSET,(IIDATE(I),I=1,9),(ITIME(I),I=1,8)
  115 FORMAT(' ',T14,'SET # ',I4,11X,9A1,11X,8A1)
      REWIND 6
      OPEN(UNIT=3,TYPE='NEW',INITIALSIZE=INTSIZ,RECORDSIZE=RECSIZ
     >,NAME=FNAME,ACCESS='DIRECT',FORM='UNFORMATTED')
C
C  INIT FLAGS & START PROFILE RUN
C
  120 DFLAG=0
      ERRFLG=0
      CALL SNDCOM
C
C  GET TIME AND DATE
C
  125 CALL GTIM(TIM2)
      CALL IDATE(MN,DAY,YR)
      CALL TIMASC(TIM2,ITIME)
      CALL DATE(IIDATE)
C
C  WAIT FOR PROFILE
C
  130 ICHAR=ITTINR()
      JCHAR=ICHAR
      IF(JCHAR.EQ.'S') GOTO 195
```

```
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0065          IF(DFLAG.NE.1)GOTO 130
0067          IF(ERRFLG.EQ.1)GOTO 200
0069          CALL DISCAL
0070          WRITE(3'CPROF) BINS,LBI,CSET,CPROF,MN,DAY,YR,TIM2
             >,(LDATA(K),K=LBI,HBI)
        C
        C  UPDATE & CHECK COUNTERS
        C
0071          LPROF=CPROF
0072          CPROF=CPROF+1
0073          IF(CPROF.GT.PROFS)GOTO 140
        C
        C  INTER-PROFILE DELAY
        C
0075          CALL GTIM(TIML)
0076          CALL JJCVT(TIML)
0077      135 CALL GTIM(TIMH)
0078          CALL JJCVT(TIMH)
0079          CALL JSUB(TIMH,TIML,STIM)
0080          IF(STIM.LT.0)TIM2=0
0082          IF(DTIM.GT.STIM)GOTO 135
        C
0084          DFLAG=0
0085          ERRFLG=0
0086          CALL SNDDTR
0087          GOTO 125
        C ---------------------------------------
        C  SET COMPLETED
        C ---------------------------------------
0088      140 CLOSE(UNIT=3)
0089          CSET=CSET+1
0090          CPROF=1
0091          CALL FORSCN
0092          TYPE 150,LSET
0093          CALL BAKSCN
0094          PAUSE 'Press  RETURN to continue'
0095      145 RETURN
0096      150 FORMAT(' ',//,' SET # ',I4,' -- COMPLETED')
        C =======================================
        C  PROFILE ERROR
        C =======================================
        C  CLEAR 'S' CHARACTER FROM KEYBOARD
0097      195 READ(5,80) OPT
        C  ERROR ROUTINE
0098      200 CALL CLRSCN
0099          TYPE 210
0100      210 FORMAT(' ',/////,T11,'Do you want to close out the current
             > Data Set on disk ? ',$)
0101          READ(5,80) OPT
0102          IF(OPT.EQ.'Y') GOTO 140
0104          TYPE 220
0105      220 FORMAT(' ',//,T27,'Press RETURN to try again ',$)
0106          READ(5,80) OPT
0107          GOTO 120
0108          END
```

FORTRAN IV Storage Map for Program Unit DATRUN

Local Variables, .PSECT $DATA, Size = 000136 (47. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
BINS	I*2	000034	DAY	I*2	000026	DENOM	R*4	000020
DTIM	I*4	000056	HDRB	I*2	000032	I	I*2	000066
ICHAR	I*2	000072	J	I*2	000070	JCHAR	L*1	000064
K	I*2	000074	MN	I*2	000024	MON	L*1	000063
OPT	L*1	000062	STIM	I*4	000052	TIMH	I*4	000046
TIML	I*4	000042	TIM2	I*4	000036	YR	I*2	000030

COMMON Block /DATTIM/, Size = 000021 (9. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
IIDATE	L*1	000000	ITIME	L*1	000011			

COMMON Block /DISK /, Size = 000023 (10. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
INTSIZ	I*2	000000	RECSIZ	I*2	000002	FNAME	L*1	000004

COMMON Block /PTERS /, Size = 000006 (3. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
B30	I*2	000000	B60	I*2	000002	S20	I*2	000004

COMMON Block /LREPS /, Size = 000042 (17. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
LREP	R*4	000000	LRI	R*4	000004	HRI	R*4	000010
LBI	I*2	000014	HBI	I*2	000016	BSAT	R*4	000020
BSATF	R*4	000024	EANG	R*4	000030	REANG	R*4	000034
PDEL	I*2	000040						

COMMON Block /SETS /, Size = 000006 (3. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
SETS	I*2	000000	PROFS	I*2	000002	SHOTSP	I*2	000004

COMMON Block /FLAGS /, Size = 000003 (2. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
RUNFLG	L*1	000000	DFLAG	L*1	000001	ERRFLG	L*1	000002

COMMON Block /SEND /, Size = 000004 (2. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
REPNUM	I*2	000000	MSHOTS	I*2	000002			

COMMON Block /STATS /, Size = 000010 (4. words)

Name	Type	Offset	Name	Type	Offset	Name	Type	Offset
CSET	I*2	000000	CPROF	I*2	000002	LSET	I*2	000004
LPROF	I*2	000006						

```
FORTRAN IV      Storage Map for Program Unit DATRUN

COMMON Block /CONST /, Size = 000020 (     8. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
PI      R*4   000000      C       R*4   000004      GATTIM  R*4   000010
RG      R*4   000014

COMMON Block /BUFF  /, Size = 010150 ( 2100. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
LDATA   I*2   000000

Local and COMMON Arrays:

Name      Type     Section  Offset  ------Size----- Dimensions
EXT       L*1      $DATA    000000  000003 (     2.) (3)
FNAME     L*1      DISK     000004  000017 (     8.) (15)
IIDATE    L*1      DATTIM   000000  000011 (     5.) (9)
ITIME     L*1      DATTIM   000011  000010 (     4.) (8)
LDATA     I*2      BUFF     000000  010150 ( 2100.) (2100)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type   Name    Type   Name    Type   Name    Type   Name    Type
BAKSCN  R*4    CLRSCN  R*4    DATE    R*4    DISCAL  R*4    FLOAT   R*4
FORSCN  R*4    GTIM    R*4    IDATE   I*2    IFIX    I*2    ITTINR  I*2
JICVT   I*2    JJCVT   I*2    JSUB    I*2    SIN     R*4    SNDCOM  R*4
SNDDTR  R*4    SQRT    R*4    TIMASC  R*4    TIME    R*4
```

III.8 EXMPRF

```
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C ***************************************
C
C  SUBROUTINE EXMPRF - EXAMINE PROFILE
C                D.VOELZ
C
C ***************************************
C
C  THIS SUBROUTINE DISPLAYS A SELECTED PROFILE
C  FROM THE DATA DISK ON THE TERMINAL AND PRINTER.
C
      SUBROUTINE EXMPRF
      INTEGER DSET,DPROF,BINS,LBI,CSET,CPROF,MN,DAY,YR
     >,LDATA(2100),HDRB,NXTL,LSTL,ICNT,BCNT,BNMBR,INMBR
     >,LNMBR,INTSIZ,RECSIZ
      INTEGER*4 TIM2
      LOGICAL*1 ITIME(8)
      BYTE FNAME(15),EXT(3),MON
C
      COMMON/BUFF/ LDATA
      COMMON/DISK/ INTSIZ,RECSIZ,FNAME
C
      HDRB=9
C===============================
C  RESPONSES
C===============================
      CALL CLRSCN
      TYPE 15
      TYPE 20
      READ(5,*)DSET
      IF(DSET.EQ.0)RETURN
      TYPE 30
      READ(5,*)DPROF
      IF(DPROF.EQ.0)RETURN
   20 FORMAT(' ',T5,'SET #       ',$)
   15 FORMAT(' ',T32,'EXAMINE PROFILE',///)
   30 FORMAT(' ',T5,'PROFILE #   ',$)
C
C  SET FILE NAME
C
      ENCODE(3,50,EXT)DSET
   50 FORMAT(I3)
      DO 60 I=1,3
      FNAME(7+I)='0'
   60 IF(EXT(I).NE.' ')FNAME(7+I)=EXT(I)
C
C  DETERMINE RECORD SIZE
C
      OPEN(UNIT=3,TYPE='OLD',RECORDSIZE='2',NAME=FNAME,ACCESS=
     >'DIRECT',FORM='UNFORMATTED',ERR=200)
      READ(3'1,ERR=210)BINS
      CLOSE(UNIT=3)
      RECSIZ=(BINS+HDRB+1)/2
C
C  GET DATA
```

```
      C
0032        OPEN(UNIT=3,TYPE='OLD',RECORDSIZE=RECSIZ,NAME=FNAME,ACCESS=
          >'DIRECT',FORM='UNFORMATTED',ERR=200)
0033        READ(3'DPROF,ERR=210)BINS,LBI,CSET,CPROF,MN,DAY,YR,TIM2
          >,(LDATA(K),K=1,BINS)
0034        CLOSE(UNIT=3)
      C============================
      C  DISPLAY
      C============================
      C
      C  CONVERT TIME
      C
0035        CALL TIMASC(TIM2,ITIME)
0036        K=0
      C----------------------------
      C  DISPLAY ON TERMINAL
      C----------------------------
      C
      C  SET UP PAGE
      C
0037     70 TYPE 75,CSET,MN,DAY,YR,K+1
0038     75 FORMAT(' ',' SET #      ',I4,4X,I2,'-',I2,'-',I2,10X,I2)
0039        TYPE 77,CPROF,ITIME
0040     77 FORMAT(' ',' PROFILE # ',I4,4X,8A1)
0041        NXTL=20
0042        ICNT=1+200*K
0043        BCNT=LBI+ICNT-1
0044        IF(ICNT+199.GE.BINS)NXTL=(BINS-ICNT)/10
0046        IF(NXTL.EQ.0)GOTO 120
      C
      C  TYPE FULL LINES
      C
0048        DO 80 J=1,NXTL
0049        BNMBR=BCNT+10*(J-1)
0050        INMBR=ICNT+10*(J-1)
0051        LNMBR=ICNT+10*J-1
0052     80 TYPE 90,BNMBR,(LDATA(I),I=INMBR,LNMBR)
0053     90 FORMAT(' ',I5,'-',10I6)
0054        IF(NXTL.NE.20)GOTO 120
0056        K=K+1
0057        PAUSE
0058        GOTO 70
      C
      C  TYPE FINAL LINE
      C
0059    120 TYPE 130,BNMBR+10
0060    130 FORMAT(' ',I5,'-',$)
0061        DO 140 K=LNMBR+1,BINS
0062    140 TYPE 150,LDATA(K)
0063    150 FORMAT(I7,$)
0064        TYPE 160
0065    160 FORMAT(' ')
0066        PAUSE 'LAST PAGE'
      C----------------------------
```

```
C  PRINT OUT
C-----------------------------
  165 TYPE 170
  170 FORMAT('0',T20,'Do you want a printout ? ',$)
      READ(5,175,ERR=165)MON
  175 FORMAT(A1)
      IF(MON.NE.'Y')GOTO 190
C
C  SET UP PAGE
C
      PRINT 176,CSET,MN,DAY,YR
  176 FORMAT(' ',' SET#        ',I4,4X,I2,'-',I2'-',I2)
      PRINT 77,CPROF,ITIME
      LSTL=IFIX(FLOAT(BINS)/10.+.99)
C
C  PRINT LINES
C
      DO 177 J=1,LSTL
      BNMBR=LBI+10*(J-1)
      INMBR=1+10*(J-1)
      LNMBR=10*J
      PRINT 90,BNMBR,(LDATA(I),I=INMBR,LNMBR)
  177 CONTINUE
      REWIND 6
C
  190 RETURN
C-----------------------------
C  ERROR CONDITIONS
C-----------------------------
  200 PAUSE '?? FILE OPENING ERROR'
      RETURN
C
  210 PAUSE '?? FILE READ ERROR'
      CLOSE(UNIT=3)
      RETURN
C
      END
```

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```
FORTRAN IV      Storage Map for Program Unit EXMPRF

Local Variables, .PSECT $DATA, Size = 000130 (   44. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
BCNT   I*2   000060      BINS   I*2   000032      BNMBR  I*2   000062
CPROF  I*2   000040      CSET   I*2   000036      DAY    I*2   000044
DPROF  I*2   000030      DSET   I*2   000026      HDRB   I*2   000050
I      I*2   000076      ICNT   I*2   000056      INMBR  I*2   000064
J      I*2   000102      K      I*2   000100      LBI    I*2   000034
LNMBR  I*2   000066      LSTL   I*2   000054      MN     I*2   000042
MON    L*1   000074      NXTL   I*2   000052      TIM2   I*4   000070
YR     I*2   000046

COMMON Block /BUFF  /, Size = 010150 ( 2100. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
LDATA  I*2   000000

COMMON Block /DISK  /, Size = 000023 (   10. words)

Name   Type  Offset      Name   Type  Offset      Name   Type  Offset
INTSIZ I*2   000000      RECSIZ I*2   000002      FNAME  L*1   000004

Local and COMMON Arrays:

Name     Type   Section Offset  ------Size----- Dimensions
EXT    L*1      $DATA   000010  000003 (     2.) (3)
FNAME  L*1      DISK    000004  000017 (     8.) (15)
ITIME  L*1      $DATA   000000  000010 (     4.) (8)
LDATA  I*2      BUFF    000000  010150 ( 2100.) (2100)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name   Type   Name   Type   Name   Type   Name   Type   Name   Type
CLRSCN  R*4   FLOAT   R*4   IFIX    I*2   TIMASC  R*4
```

III.9 DISCAL

```
FORTRAN IV      V02.5-5    Tue 31-May-83 15:22:06                PAGE 001
C    ************************************************
C
C    SUBROUTINE DISCAL.FOR - DATA CALCULATIONS AND DISPLAY
C                        D.VOELZ
C
C    ************************************************
C
C    THIS SUBROUTINE PROCESSES INCOMING SODIUM LIDAR PROFILES.
C    IT CALCULATES AND DISPLAYS PARTICULAR VALUES OF INTEREST.
C
        SUBROUTINE DISCAL
        INTEGER CSET,CPROF,LSET,LPROF,INTSIZ
       >,RECSIZ,B30,B60,S20,LDATA(2100),K30,K60,K80,K100
       >,SGP,TSGP,AK30,AK60,AK80,AK100,ASGP,ATSGP
       >,REPNUM,MSHOTS,LBI,HBI,PDEL
        REAL CLA,ACLA,RAYC,LREP,LRI,HRI,EANG,REANG,BSAT,BSATF
        LOGICAL*1 IDATE(9),ITIME(8)
        BYTE RUNFLG,DFLAG,ERRFLG
C
        COMMON /DATTIM/ IDATE,ITIME
        COMMON /STATS/ CSET,CPROF,LSET,LPROF
        COMMON /CALCS/ K30,K60,K80,K100,SGP,TSGP,CLA
        COMMON /FLAGS/ RUNFLG,DFLAG,ERRFLG
        COMMON /PTERS/ B30,B60,S20
        COMMON /BUFF/ LDATA
        COMMON /SEND/ REPNUM,MSHOTS
        COMMON /LREPS/ LREP,LRI,HRI,LBI,HBI,BSAT,BSATF,EANG,
       >REANG,PDEL
C
        CALL CLRSCN
C
C------------------------------
C  CALCULATIONS
C------------------------------
        AK30=0
        AK60=0
        AK80=0
        AK100=0
C  CALCULATE K30
        DO 10 I=1,5
  10      AK30=AK30+LDATA(B30-3+I)
          AK30=IFIX(FLOAT(AK30)/5.+.5)
C  CALCULATE K60,K80,100
        DO 20 I=1,S20
          AK60=AK60+LDATA(B60-1+I)
          AK80=AK80+LDATA(B60-1+I+S20)
  20      AK100=AK100+LDATA(B60-1+I+S20+S20)
C  CALCULATE SIGNAL PHOTONS
        ATSGP=AK80-AK60
        ASGP=IFIX(FLOAT(ATSGP)/MSHOTS+.5)
C  COLUMN ABUNDANCE RATIO
        RAYC=FLOAT(AK30)-FLOAT(AK60)/S20
        ACLA=0.
        IF(RAYC.LE.0.)GOTO 25
```

```
0032          ACLA=FLOAT(ATSGP)/RAYC
        C----------------------------
        C  CHECK RUN FLAG
        C----------------------------
0033       25 IF(RUNFLG.EQ.3)GOTO 30
        C----------------------------
        C  DATA RUN DISPLAY
        C----------------------------
0035          K30=AK30
0036          K60=AK60
0037          K80=AK80
0038          K100=AK100
0039          SGP=ASGP
0040          TSGP=ATSGP
0041          CLA=ACLA
        C
0042          TYPE 40
0043          TYPE 50,(IDATE(I),I=1,9),(ITIME(I),I=1,8)
0044          TYPE 60,CSET,CPROF
0045          TYPE 70,MSHOTS
0046          TYPE 72,BSAT
0047          TYPE 80,K30,K60,K80,K100
0048          TYPE 90,TSGP
0049          TYPE 100,SGP
0050          TYPE 110,CLA
        C
0051          PRINT 50,(IDATE(I),I=1,9),(ITIME(I),I=1,8)
0052          PRINT 60,CSET,CPROF
0053          PRINT 70,MSHOTS
0054          PRINT 72,BSAT
0055          PRINT 80,K30,K60,K80,K100
0056          PRINT 90,TSGP
0057          PRINT 100,SGP
0058          PRINT 110,CLA
0059          PRINT 47
0060          REWIND 6
        C
0061          RETURN
        C----------------------------
        C SODIUM ALIGNMENT RUN DISPLAY
        C----------------------------
0062       30 TYPE 45
0063          TYPE 50,(IDATE(I),I=1,9),(ITIME(I),I=1,8)
0064          TYPE 70,MSHOTS
0065          TYPE 72,BSAT
0066          TYPE 80,AK30,AK60,AK80,AK100
0067          TYPE 90,ATSGP
0068          TYPE 100,ASGP
0069          TYPE 110,ACLA
        C
0070          RETURN
        C----------------------------
        C  FORMAT STATEMENTS
        C----------------------------
```

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```
FORTRAN IV      V02.5-5     Tue 31-May-83 15:22:06                PAGE 003

0071       40 FORMAT(' ',/,T35,'DATA RUN',/)
0072       45 FORMAT(' ',/,T30,'SODIUM ALIGNMENT RUN',/)
0073       47 FORMAT(' ',T23,'--------------------------------')
0074        ) FORMAT(' ',T35,9A1,/T35,8A1,)
0075       60 FORMAT(' ',T33,'Set #       ',I4,/T33,'Profile # ',I4,/)
0076       70 FORMAT(' ',T23,'Laser Shots Per Profile   =',I6)
0077       72 FORMAT(' ',T23,'Base Altitude Setting     =',F6.2)
0078       80 FORMAT(' ',T23,'Detected Photons:',/T38,'at 30 Km   =',I6,
             >/T35,'60 -  80 Km   =',I6,/T35,'80 - 100 Km   =',I6,/T34,'100
             > - 120 Km   =',I6)
0079       90 FORMAT(' ',T23,'Total Signal Photons      =',I6)
0080      100 FORMAT(' ',T23,'Signal Photons Per Shot   =',I6)
0081      110 FORMAT(' ',T23,'Column Abundance Ratio    =',F6.2)
0082          END
```

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```
FORTRAN IV      Storage Map for Program Unit DISCAL

Local Variables, .PSECT $DATA, Size = 000070 (   28. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
ACLA    R*4   000036      AK100   I*2   000030      AK30    I*2   000022
AK60    I*2   000024      AK80    I*2   000026      ASGP    I*2   000032
ATSGP   I*2   000034      I       I*2   000046      INTSIZ  I*2   000016
RAYC    R*4   000042      RECSIZ  I*2   000020

COMMON Block /DATTIM/, Size = 000021 (    9. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
IDATE   L*1   000000      ITIME   L*1   000011

COMMON Block /STATS /, Size = 000010 (    4. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
CSET    I*2   000000      CPROF   I*2   000002      LSET    I*2   000004
LPROF   I*2   000006

COMMON Block /CALCS /, Size = 000020 (    8. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
K30     I*2   000000      K60     I*2   000002      K80     I*2   000004
K100    I*2   000006      SGP     I*2   000010      TSGP    I*2   000012
CLA     R*4   000014

COMMON Block /FLAGS /, Size = 000003 (    2. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
RUNFLG  L*1   000000      DFLAG   L*1   000001      ERRFLG  L*1   000002

COMMON Block /PTERS /, Size = 000006 (    3. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
B30     I*2   000000      B60     I*2   000002      S20     I*2   000004

COMMON Block /BUFF  /, Size = 010150 ( 2100. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
LDATA   I*2   000000

COMMON Block /SEND  /, Size = 000004 (    2. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
REPNUM  I*2   000000      MSHOTS  I*2   000002

COMMON Block /LREPS /, Size = 000042 (   17. words)

Name    Type  Offset      Name    Type  Offset      Name    Type  Offset
LREP    R*4   000000      LRI     R*4   000004      HRI     R*4   000010
LBI     I*2   000014      HBI     I*2   000016      BSAT    R*4   000020
BSATF   R*4   000024      EANG    R*4   000030      REANG   R*4   000034
PDEL    I*2   000040
```

```
FORTRAN IV      Storage Map for Program Unit DISCAL

Local and COMMON Arrays:

Name    Type   Section Offset  ------Size----- Dimensions
IDATE   L*1    DATTIM  000000  000011 (    5.) (9)
ITIME   L*1    DATTIM  000011  000010 (    4.) (8)
LDATA   I*2    BUFF    000000  010150 ( 2100.) (2100)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type   Name    Type   Name    Type    Name    Type    Name    Type
CLRSCN  R*4    FLOAT   R*4    IFIX    I*2
```

III.10 RCVER

```
RCVER.MAC   MACRO V04.00  31-MAY-83 15:40:37 PAGE 1

                                  ;****************************************
                                  ;
                                  ;  LSI-11 RECEIVER
                                  ;      D.VOELZ
                                  ;
                                  ;****************************************
                                          .TITLE  RCVER.MAC
                                          .MCALL  .INTEN,.PROTECT
                                          .GLOBL  HDUMP,SNDACK,INITR,MOUT
   000000                                 .CSECT  RCVER
                                  ;
                                  ;  I/O LOCATIONS
                                  ;
           176500                 RCSR=176500             ;DLV11-J CHN.0 LOCATIONS
           176502                 RBUF=RCSR+2
           000300                 PCVEC=300
           000302                 STVEC=PCVEC+2
                                  ;
                                  ;  GENERAL PARAMETERS
                                  ;
           000340                 PR7=340                 ;PRIORITY LEVEL 7
           000003                 ERRCNT=3                ;ERROR COUNT
           000063                 PRDONE=063              ;OPCODES-PROFILE DONE
           000064                 ACK=064                 ;        -ACKNOWLEDGE
           000071                 DATEND=071              ;        -END OF DATA
           000201                 CTX=201                 ;'CTX' CHAR
           000202                 ETX=202                 ;'ETX' CHAR
           000203                 STX=203                 ;'STX' CHAR
           000220                 DLE=220                 ;'DLE' CHAR
                                  ;
                                  ;  DATA PACKET PARAMETERS
                                  ;
           000120                 OPCLO=120               ;LO BYTE DATA OPCODE
           000340                 OPCHI=340               ;HI BYTE DATA OPCODE
           003720                 PAKLEN=2000.            ;PACKET LENGTH (MAX=32767)
                                  ;
                                  ;----------------------------------------
                                  ;  INITIALIZE RECEIVER
                                  ;----------------------------------------
   000000                         INITR:: .PROTECT        #PAREA,#300
   000020  012737  000062' 000300         MOV     #IOINT,@#PCVEC  ;SET UP PC VECTOR
   000026  012737  000340  000302         MOV     #PR7,@#STVEC    ;SET UP STATUS WORD VECTOR
   000034  012767  000144' 000000'        MOV     #STPAK1,STATE   ;SET INPUT BYTE VECTOR
   000042  000207                         RTS     PC
                                  ;----------------------------------------
                                  ;  HEX MEMORY DUMP OF ARRAY LDATA
                                  ;----------------------------------------
   000044  012701  000000'        MOUT::  MOV     #LDATA,R1
   000050  012702  007640                 MOV     #4000.,R2
   000054  004767  000000G                JSR     PC,HDUMP
   000060  000207                         RTS     PC
                                  ;
                                  ;----------------------------------------
                                  ;  INTERRUPT POINTS
                                  ;----------------------------------------
                                  ;
                                  ;  INTERRUPT ENTRY POINT
```

```
                                        ;
000062                                  IOINT:  .INTEN  7               ;ALERT RT-11 OF INTERRUPT
000070  010046                                  MOV     R0,-(SP)        ;SAVE REGISTERS
000072  010146                                  MOV     R1,-(SP)
000074  010246                                  MOV     R2,-(SP)
000076  010346                                  MOV     R3,-(SP)
                                        ;
000100  016701  000000'                         MOV     STATE,R1        ;MOVE INPUT BYTE VECTOR TO R1
                                        ;
000104  113700  176502                          MOVB    @#RBUF,R0       ;LOAD R0 WITH INPUT BYTE
000110  000111                                  JMP     (R1)            ;GO TAKE CARE OF INPUT BYTE
                                        ;
                                        ;  INTERRUPT EXIT POINT
                                        ;
000112  042700  177400                  GETBT:  BIC     #177400,R0      ;CLEAR HI BYTE OF R0
000116  060067  000002'                         ADD     R0,RCSUM        ;UPDATE RECD CHECKSUM
                                        ;
000122  012667  000000'                         MOV     (SP)+,STATE     ;SET NEW INPUT BYTE VECTOR
                                        ;
000126  012603                                  MOV     (SP)+,R3        ;RESTORE REGISTERS
000130  012602                                  MOV     (SP)+,R2
000132  012601                                  MOV     (SP)+,R1
000134  012600                                  MOV     (SP)+,R0
000136  000207                                  RTS     PC
                                        ;
                                        ;----------------------------------------
                                        ;  PACKET RECEIVING
                                        ;----------------------------------------
000140  004767  177746                  STPAK:  JSR     PC,GETBT
000144  120027  000220                  STPAK1: CMPB    R0,#DLE         ;CHECK FOR 'DLE' BYTE
000150  001373                                  BNE     STPAK
                                        ;
000152  004767  177734                          JSR     PC,GETBT
000156  120027  000203                          CMPB    R0,#STX         ;CHECK FOR 'STX' BYTE
000162  001366                                  BNE     STPAK
000164  005067  000002'                 OPPAK:  CLR     RCSUM           ;CLEAR RECD CHECKSUM ACCUMULATOR
                                        ;
000170  004767  177716                          JSR     PC,GETBT        ;GET OPCODE
000174  110067  000016'                         MOVB    R0,OPCDE        ;  SAVE IT
                                        ;
                                        ;  VERIFY CHECKSUM
                                        ;
000200  004767  177706                  VERCHK: JSR     PC,GETBT        ;GET 'DLE' BYTE
000204  004767  177702                          JSR     PC,GETBT        ;GET 'ETX' BYTE
000210  016767  000002' 000004'         VERIFY: MOV     RCSUM,SAVSUM    ;SAVE RECD CHECKSUM
                                        ;
000216  004767  177670                          JSR     PC,GETBT        ;GET LO BYYE XMITTED CHECKSUM
000222  120067  000004'                         CMPB    R0,SAVSUM       ;  CHECK IT
000226  001344                                  BNE     STPAK
000230  004767  177656                          JSR     PC,GETBT        ;GET HI BYTE XMITTED CHECKSUM
000234  000367  000004'                         SWAB    SAVSUM
000240  120067  000004'                         CMPB    R0,SAVSUM       ;  CHECK IT
000244  001335                                  BNE     STPAK
                                        ;
                                        ;  DECIPHER OPCODE
                                        ;
000246  116701  000016'                         MOVB    OPCDE,R1        ;MOVE OPCODE TO R1
```

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                                         ;
000252  122701  000064                           CMPB    #ACK,R1          ;  ACK ?
000256  001433                                   BEQ     ACKN
000260  122701  000071                           CMPB    #DATEND,R1       ;  DATA PACKET COMPLETED ?
000264  001003                                   BNE     PRFCHK           ;   -NO,GO ON
000266  004767  000000G                          JSR     PC,SNDACK        ;   -YES,SEND ACK
000272  000722                                   BR      STPAK
000274  122701  000063                   PRFCHK: CMPB    #PRDONE,R1       ;  PROFILE COMPLETED ?
000300  001011                                   BNE     DATCHK           ;   -NO,GO ON
000302  004767  000000G                          JSR     PC,SNDACK        ;   -YES,SEND ACK
000306  112767  000001  000001'                  MOVB    #1,DFLAG         ;     SET DATA RUN FLAG
000314  042737  000100  175500                   BIC     #100,@#RCSR      ;     DISABLE DLV11-J INTERRUPT
000322  000706                                   BR      STPAK
000324  042701  000017                   DATCHK: BIC     #17,R1           ;CLEAR LOWER 4 BITS OF OPCODE
000330  122701  000120                           CMPB    #OPCLO,R1        ;  LOW BYTE DATA ?
000334  001410                                   BEQ     LBYTES
000336  122701  000340                           CMPB    #OPCHI,R1        ;  HI BYTE DATA ?
000342  001410                                   BEQ     HBYTES
000344  000675                                   BR      STPAK            ;BAD OPCODE
                                         ;
                                         ;------------------------------------
                                         ;  RECEIVED ACKNOWLEDGE
                                         ;------------------------------------
000346  112767  000001  000000'          ACKN:   MOVB    #1,ACKFLG        ;SET ACK FLAG
000354  000671                                   BR      STPAK
                                         ;------------------------------------
                                         ;  RECEIVE DATA FRAME
                                         ;------------------------------------
                                         ;
                                         ;  DETERMINE BASE ADDRESS FOR DATA FRAME
                                         ;
000356  012704  000000'                  LBYTES: MOV     #LDATA,R4        ;SET BASE ADDRESS FOR LO BYTES
000362  000402                                   BR      DATFRM
000364  012704  000001'                  HBYTES: MOV     #<LDATA+1>,R4    ;SET BASE ADDRESS FOR HI BYTES
                                         ;
000370  012703  007640                   DATFRM: MOV     #<2*PAKLEN>,R3   ;MOVE DOUBLE PACKET LENGTH INTO R3
000374  116701  000016'                          MOVB    OPCDE,R1         ;MOVE OPCODE INTO R1
000400  112767  000071  000016'                  MOVB    #DATEND,OPCDE    ;LOAD 'DATEND' OPCODE
                                         ;
000406  042701  177760                           BIC     #177760,R1       ;CLEAR HI 12 BITS OF OPCODE
000412  070301                                   MUL     R1,R3            ;MULT. ADJSTD. OPCODE & DBL. PACKET LENGTH
000414  060304                                   ADD     R3,R4            ;ADD ADDRESS BASE & ADDRESS OFFSET
000416  010467  000006'                          MOV     R4,STADD         ;SAVE DATA PACKET STARTING ADDRESS
                                         ;
                                         ;  RECEIVE DATA BYTES
                                         ;
000422  004767  177464                           JSR     PC,GETBT
000426  120027  000220                           CMPB    R0,#DLE          ;CHECK FOR 'DLE' CHARACTER
000432  001242                                   BNE     STPAK
                                         ;
000434  004767  177452                           JSR     PC,GETBT
000440  120027  000201                           CMPB    R0,#CTX          ;CHECK FOR 'CTX' CHARACTER
000444  001235                                   BNE     STPAK
000446  005067  000002'                          CLR     RCSUM            ;CLEAR RECD CHECKSUM ACCUMULATOR
                                         ;
000452  004767  177434                   DATA:   JSR     PC,GETBT         ;GET DATA BYTE
000456  120027  000220                           CMPB    R0,#DLE          ;  CHECK FOR 'DLE' CHARACTER
```

```
000462  001407                       BEQ     CHKDBL
                             ;
000464  016704  000006'      OKDBL:  MOV     STADD,R4
000470  110024                       MOVB    R0,(R4)+        ; DEPOSIT BYTE
000472  005204                       INC     R4
000474  010467  000006'              MOV     R4,STADD
000500  000764                       BR      DATA
                             ;
000502  004767  177404       CHKDBL: JSR     PC,GETBT        ;THROW AWAY FIRST 'DLE'
000506  120027  000220               CMPB    R0,#DLE         ;  DLE ?
000512  001764                       BEQ     OKDBL
000514  120027  000203       ENDIT:  CMPB    R0,#ETX         ;  ETX ? (FRAME DONE)
000520  001633                       BEQ     VERIFY
000522  000167  177412               JMP     STPAK           ;FRAME ENDER ERROR
                             ;
                             ;
000000                               .PSECT  RCV,RW,D,LCL,REL,CON
000000                       STATE:  .BLKW   1
000002                       RCSUM:  .BLKW   1
000004                       SAVSUM: .BLKW   1
000006                       STADD:  .BLKW   1
000010                       PAREA:  .BLKW   3
000016                       OPCDE:  .BLKB   1
                             ;
000000                               .PSECT  ACKFLG,RW,D,GBL,REL,OVR
000000                       ACKFLG: .BLKB   1
                             ;
000000                               .PSECT  BUFF,RW,D,GBL,REL,OVR
000000                       LDATA:  .BLKW   2100.
                             ;
000000                               .PSECT  FLAGS,RW,D,GBL,REL,OVR
000000                       RUNFLG: .BLKB   1
000001                       DFLAG:  .BLKB   1
000002                       ERRFLG: .BLKB   1
                             ;
        000001                       .END
```

ORIGINAL PAGE IS
OF POOR QUALITY


```
RCVER.MAC       MACRO V04.00  31-MAY-83 15:40:37 PAGE 1-4
SYMBOL TABLE

ACK    = 000064          DLE    = 000220          LBYTES   000356R      002 PCVEC  = 000300          STADD    000006R   003
ACKFLG   000000R     004 ENDIT    000514R     002 LDATA    000000R      005 PRDONE= 000063           STATE    000000R   003
ACKN     000346R     002 ERRCNT= 000003           MOUT     000044RG     002 PRFCHK   000274R     002 STPAK    000140R   002
CHKDBL   000502R     002 ERRFLG   000002R     006 OKDBL    000464R      002 PR7    = 000340          STPAK1   000144R   002
CTX    = 000201          ETX    = 000202          OPCDE    000016R      003 RBUF   = 176502          STVEC  = 000302
DATA     000452R     002 GETBT    000112R     002 OPCHI  = 000340           RCSR   = 176500          STX    = 000203
DATCHK   000324R     002 HBYTES   000364R     002 OPCLO  = 000120           RCSUM    000002R     003 VERCHK   000200R   002
DATEND= 000071           HDUMP  = ****** G        OPPAK    000164R      002 RUNFLG   000000R     006 VERIFY   000210R   002
DATFRM   000370R     002 INITR    000000RG    002 PAKLEN= 003720            SAVSUM   000004R     003 ...V1  = 000003
DFLAG    000001R     006 IOINT    000062R     002 PAREA    000010R      003 SNDACK= ****** G

. ABS.   000000      000
         000000      001
RCVER    000526      002
RCV      000017      003
ACKFLG   000001      004
BUFF     010150      005
FLAGS    000003      006
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  9216 WORDS  ( 36 PAGES)
DYNAMIC MEMORY AVAILABLE FOR  54 PAGES
RCVER,LP:=RCVER.MAC
```

III.11 SENDER

SENDER.MAC MACRO V04.00 31-MAY-83 15:45:58 PAGE 1

```
                                        ;****************************************
                                        ;
                                        ;  LSI-11 SENDER
                                        ;     D.VOELZ
                                        ;
                                        ;****************************************
                                               .TITLE SENDER.MAC
                                               .MCALL  .TTYOUT,.PRINT,.TTYIN
                                               .GLOBL  SNDACK,SNDDTR,SNDCOM,CLRSCN
 000000                                        .CSECT  SENDER
                                        ;
                                        ;  I/O LOCATIONS
                                        ;
          176500                        RCSR=176500             ;DLV11-J CHN.C LOCATIONS
          176502                        RBUF=RCSR+2
          176504                        XCSR=RCSR+4
          176506                        XBUF=RCSR+6
                                        ;
                                        ;  GENERAL PARAMETERS
                                        ;
          000003                        ERRCNT=3                ;ERROR COUNT
          000061                        DRUN=061                ;OPCODES-DATA RUN
          000062                        COM=062                 ;       -COMMANDS
          000064                        ACK=064                 ;       -ACKNOWLEDGE
          000201                        CTX=201                 ;'CTX' CHAR
          000202                        ETX=202                 ;'ETX' CHAR
          000203                        STX=203                 ;'STX' CHAR
          000220                        DLE=220                 ;'DLE' CHAR
                                        ;
                                        ;  MACRO DIRECTIVE - AKWAIT
                                        ;    THIS MACRO DIRECTIVE IS THE TIME-OUT LOOP FOR AN
                                        ;    ACKNOWLEDGE. IF THE ACKNOWLEDGE FLAG (ACKFLG) IS
                                        ;    NOT SET WHILE THE ROUTINE IS IN ITS LOOP, PROGRAM
                                        ;    CONTROL JUMPS TO THE ERROR ROUTINE 'ERROUT'.
                                        ;
                                               .MACRO  AKWAIT  JMPADD,?A,?B,?C
                                               MOV     2000.,R0
                                        A:     CMPB    ACKFLG,#1
                                               BEQ     C
                                               DEC     R0
                                               BNE     A
                                        B:     DEC     R3
                                               BNE     JMPADD
                                               JMP     ERROUT
                                        C:     NOP
                                               .ENDM   AKWAIT
                                        ;
                                        ;========================================
                                        ;  SEND ACKNOWLEDGE
                                        ;========================================
 000000   112767  000064  000002'  SNDACK::MOVB    #ACK,OPCDE      ;LOAD 'ACK' OPCODE
 000006   004767  000162                       JSR     PC,SNDFRM       ;SEND ACK FRAME
 000012   000207                               RTS     PC
                                        ;
                                        ;========================================
                                        ;  SEND DATA RUN FRAME
                                        ;========================================
```

```
000014  052737  000100  176500  SNDDTR::BIS     #100,@#RCSR
000022  112767  000061  000002'         MOVB    #DRUN,OPCDE     ;LOAD 'DRUN' OPCODE
000030  012703  000003                  MOV     #ERRCNT,R3      ;SET ERROR COUNT
000034  105067  000000'         SNDTR1: CLRB    ACKFLG          ;CLEAR ACK FLAG
000040  004767  000130                  JSR     PC,SNDFRM       ;SEND DATA RUN FRAME
000044                                  AKWAIT  SNDTR1          ;WAIT FOR ACK
000076  000207                          RTS     PC
                                ;
                                ;========================================
                                ;  SEND COMMANDS FRAME
                                ;========================================
000100  052737  000100  176500  SNDCOM::BIS     #100,@#RCSR
000106  112767  000062  000002'         MOVB    #COM,OPCDE      ;LOAD 'COMMANDS' OPCODE
000114  012703  000003                  MOV     #ERRCNT,R3      ;SET ERROR COUNT
000120  105067  000000'         SNCOM1: CLRB    ACKFLG          ;CLEAR ACK FLAG
000124  004767  000044                  JSR     PC,SNDFRM       ;SEND COMMANDS FRAME PART 1
000130  004767  000132                  JSR     PC,SNDCM2       ;SEND COMMANDS FRAME PART 2
000134                                  AKWAIT  SNCOM1
000166  004767  177622                  JSR     PC,SNDDTR       ;SEND DATA RUN FRAME
000172  000207                          RTS     PC
                                ;
                                ;----------------------------------------
                                ;  GENERAL PACKET SENDING ROUTINE
                                ;----------------------------------------
000174  112700  000220          SNDFRM: MOVB    #DLE,R0
000200  004767  000146                  JSR     PC,SNDBYT       ;SEND 'DLE' CHARACTER
000204  005001                          CLR     R1              ;CLEAR XMIT CHECKSUM
                                ;
000206  112700  000203                  MOVB    #STX,R0
000212  004767  000126                  JSR     PC,UPDTCK       ;UPDATE XMIT CHECKSUM & SEND 'STX'
                                ;
000216  116700  000002'                 MOVB    OPCDE,R0
000222  004767  000116                  JSR     PC,UPDTCK       ;UPDATE XMIT CHECKSUM & SEND OPCODE
                                ;
000226  112700  000220          ENDER:  MOVB    #DLE,R0
000232  004767  000106                  JSR     PC,UPDTCK       ;UPDATE XMIT CHECKSUM & SEND 'DLE'
                                ;
000236  112700  000202                  MOVB    #ETX,R0
000242  004767  000104                  JSR     PC,SNDBYT       ;SEND 'ETX' CHARACTER
                                ;
000246  110100                  SNDCHK: MOVB    R1,R0           ;SEND XMIT CHECKSUM
000250  004767  000076                  JSR     PC,SNDBYT       ;  LO BYTE
000254  000301                          SWAB    R1
000256  110100                          MOVB    R1,R0
000260  004767  000066                  JSR     PC,SNDBYT       ;  HI BYTE
000264  000207                          RTS     PC
                                ;
                                ;----------------------------------------
                                ;  SEND COMMANDS FRAME PART 2
                                ;----------------------------------------
000266  112700  000220          SNDCM2: MOVB    #DLE,R0
000272  004767  000054                  JSR     PC,SNDBYT       ;SEND 'DLE' CHARACTER
000276  005001                          CLR     R1              ;CLEAR XMIT CHECKSUM
                                ;
000300  112700  000201                  MOVB    #CTX,R0
000304  004767  000034                  JSR     PC,UPDTCK       ;UPDATE XMIT CHECKSUM & SEND 'CTX'
                                ;
```

```
000310  116700  000000'                 MOVB    REPNUM,R0
000314  004767  000024                  JSR     PC,UPDTCK       ;SEND REP NUMBER
                                ;
000320  116700  000002'                 MOVB    MSHOTS,R0       ;SEND MSHOTS
000324  004767  000014                  JSR     PC,UPDTCK       ;  LO BYTE
000330  016700  000002'                 MOV     MSHOTS,R0
000334  000300                          SWAB    R0
000336  004767  000002                  JSR     PC,UPDTCK       ;  HI BYTE
                                ;
000342  000731                          BR      ENDER           ;SEND PACKET ENDER
                                ;
                                ;
                                ;--------------------------------------
                                ; UPDATE CHECKSUM & SEND BYTE
                                ;        ROUTINES
                                ;--------------------------------------
000344  042700  177400          UPDTCK: BIC     #177400,R0      ;CLEAR HI BYTE OF R0
000350  060001                          ADD     R0,R1           ;UPDATE CHECKSUM
                                ;
000352  032737  000200  176504  SNDBYT: BIT     #200,@#XCSR     ;CHECK STATUS REG
000360  001774                          BEQ     SNDBYT
000362  110037  176506                  MOVB    R0,@#XBUF       ;OUTPUT R0
000366  000207                          RTS     PC
                                ;
                                ;--------------------------------------
                                ; ERROR MESSAGE
                                ;--------------------------------------
000370  004767  000000G         ERROUT: JSR     PC,CLRSCN
000374                                  .PRINT  #ERRMSG
000402                                  .TTYIN                  ;GET RESPONSE
000406  110001                          MOVB    R0,R1           ;  STORE IT
000410                                  .TTYIN                  ;PICK UP LF
000414                                  .TTYIN                  ;PICK UP CR
000420  120127  000131                  CMPB    R1,#'Y          ;CHECK RESPONSE
000424  001002                          BNE     EDONE
000426  000167  177446                  JMP     SNDCOM
000432  112767  000001  000001' EDONE:  MOVB    #1,DFLAG        ;SET DONE FLAG
000440  112767  000001  000002'         MOVB    #1,ERRFLG       ;SET ERROR FLAG
000446  042737  000100  176500          BIC     #100,@#RCSR     ;DISABLE DLV11-J INTERRUPT
000454  000207                          RTS     PC
                                ;
000000                                  .PSECT  MSGR,RW,D,LCL,REL,CON
000000     015     012     012  ERRMSG: .BYTE   15,12,12,12,12,12,12,12,12
000003     012     012     012
000006     012     012     012
000011     040     040     040          .ASCII  /                       COMMAND TRANSMISSION ERROR/
000014     040     040     040
000017     040     040     040
000022     040     040     040
000025     040     040     040
000030     040     040     040
000033     040     040     040
000036     040     040     040
000041     040     040     040
000044     103     117     115
000047     115     101     116
000052     104     040     124
```

```
    000055   122   101   116
    000060   123   115   111
    000063   123   123   111
    000066   117   116   040
    000071   105   122   122
    000074   117   122
    000076   015   012   012            .BYTE   15,12,12
    000101   040   040   040            .ASCII  /                    /
    000104   040   040   040
    000107   040   040   040
    000112   040   040   040
    000115   040   040   040
    000120   040   040   040
    000123   040   040
    000125   040   040   040            .ASCIZ  /              TRY AGAIN ? /<200>
    000130   040   040   040
    000133   040   040   040
    000136   040   040   040
    000141   040   040   124
    000144   122   131   040
    000147   101   107   101
    000152   111   116   040
    000155   077   040   200
    000160   000

                                 ;
    000000                              .PSECT  CCM,RW,D,LCL,REL,CON
    000000                       XCSUM:  .BLKW   1
    000002                       OPCDE:  .BLKB   1

                                 ;
    000000                              .PSECT  ACKFLG,RW,D,GBL,REL,OVR
    000000                       ACKFLG: .BLKB   1

                                 ;
    000000                              .PSECT  FLAGS,RW,D,GBL,REL,OVR
    000000                       RUNFLG: .BLKB   1
    000001                       DFLAG:  .BLKB   1
    000002                       ERRFLG: .BLKB   1

                                 ;
    000000                              .PSECT  SEND,RW,D,GBL,REL,OVR
    000000                       REPNUM: .BLKW   1
    000002                       NSHOTS: .BLKW   1

                                 ;
             000001                     .END
```

```
SENDER.MAC      MACRO V04.00  31-MAY-83 15:45:58 PAGE 1-4
SYMBOL TABLE

ACK    = 000064          DRUN   = 000061          ETX    = 000202           SNCOM1   000120R   002 SNDFRM   000174R  002
ACKFLG   000000R     005 EDONE    000432R     002 MSHOTS   000002R      007 SNDACK   000000RG  002 SNDTR1   000034R  002
CLRSCN= ****** G         ENDER    000226R     002 OPCDE    000002R      004 SNDBYT   000352R   002 STX    = 000203
COM    = 000062          ERRCNT= 000003           RBUF   = 176502           SNDCHK   000246R   002 UPDTCK   000344R  002
CTX    = 000201          ERRFLG   000002R     006 RCSR   = 176500           SNDCM2   000266R   002 XBUF   = 176506
DFLAG    000001R     006 ERRMSG   000000R     003 REPNUM   000000R      007 SNDCOM   000100RG  002 XCSR   = 176504
DLE    = 000220          ERROUT   000370R     002 RUNFLG   000000R      006 SNDDTR   000014RG  002 XCSUM    000000R  004

 . ABS.  000000     000
         000000     001
 SENDER  000456     002
 MSGR    000161     003
 CCM     000003     004
 ACKFLG  000001     005
 FLAGS   000003     006
 SEND    000004     007
 ERRORS DETECTED:  0

 VIRTUAL MEMORY USED:  8704 WORDS  ( 34 PAGES)
 DYNAMIC MEMORY AVAILABLE FOR  54 PAGES
 SENDER,LP:=SENDER.MAC
```

III.12 DISPLY

ORIGINAL PAGE IS
OF POOR QUALITY

```
DISPLY.MAC   MACRO V04.00  31-MAY-83 16:02:57 PAGE 1

                                  ;******************************************
                                  ;
                                  ;  DISPLY.MAC - VT100 TERMINAL DISPLAY ROUTINES
                                  ;                    D.VOELZ
                                  ;
                                  ;******************************************
                                  ;
                                  ;   THIS SUBPROGRAM SETS UP THE DISPLAY OF THE VT100
                                  ;   FAMILY OF TERMINALS. THE SUBROUTINES ARE AS FOLLOWS:
                                  ;         CLRSCN - CLEAR SCREEN, CURSOR TO HOME
                                  ;         FORSCN - INVERSE VIDEO
                                  ;         BAKSCN - NORMAL VIDEO
                                  ;         BELSCN - RING THE BELL
                                  ;
                                          .TITLE DISPLY.MAC
                                          .MCALL .TTYOUT
 000000                                   .CSECT  DISPLY
                                  ;
         000033                   ESC=033
         000155                   LCM=155
                                  ;
                                  ;========================================
                                  ;  VT100 DISPLAY SUBROUTINES
                                  ;========================================
 000000  012701  000054'          CLRSCN::MOV     #CLRSTR,R1
 000004  000413                           BR      OUT
 000006  012701  000064'          FORSCN::MOV     #FORSTR,R1
 000012  000410                           BR      OUT
 000014  012701  000071'          BAKSCN::MOV     #BAKSTR,R1
 000020  000405                           BR      OUT
 000022                           BELSCN::.TTYOUT BELL
 000032  000207                           RTS     PC
                                  ;-----------------------------
                                  ;  ASCII STRING OUTPUT SECTION
                                  ;-----------------------------
 000034  111100                   OUT:    MOVB    (R1),R0
 000036                                   .TTYOUT
 000042  005201                           INC     R1
 000044  121127  000000                   CMPB    (R1),#0
 000050  001371                           BNE     OUT
 000052  000207                           RTS     PC
                                  ;-----------------------------
                                  ;  ASCII STRINGS
                                  ;-----------------------------
 000054     033     133     062   CLRSTR: .BYTE   ESC,'[,'2,'J,ESC,'[,'H,0
 000057     112     033     133
 000062     110     000
 000064     033     133     067   FORSTR: .BYTE   ESC,'[,'7,LCM,0
 000067     155     000
 000071     033     133     060   BAKSTR: .BYTE   ESC,'[,'0,LCM,0
 000074     155     000
 000076     007                   BELL:   .BYTE   007
                                  ;
         000001                           .END
```

```
DISPLY.MAC      MACRO V04.00  31-MAY-83 16:02:57 PAGE 1-1
SYMBOL TABLE

BAKSCN  000014RG     002 BELSCN  000022RG     002 CLRSTR  000054R      002 FORSCN  000006RG  002 LCM    = 000155
BAKSTR  000071R      002 CLRSCN  000000RG     002 ESC    = 000033          FORSTR  000064R   002 OUT      000034R  002
BELL    000076R      002

. ABS.  000000       000
        000000       001
DISPLY  000077       002
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  8192 WORDS  ( 32 PAGES)
DYNAMIC MEMORY AVAILABLE FOR  54 PAGES
DISPLY,LP:=DISPLY
```

III.13 HDUMP

```
HDUMP.MAC   MACRO V04.00  31-MAY-83 16:04:36 PAGE 1

                                ;*****************************************
                                ;
                                ;   HEX MEMORY DUMP PROGRAM
                                ;          D.VOELZ
                                ;
                                ;*****************************************
                                ;
                                ;  THIS SUBPROGRAM DUMPS A SECTION OF THE LSI-11
                                ;  MEMORY IN HEXADECIMAL FORM.
                                ;  --- LOAD R1 WITH STARTING MEMORY ADDRESS
                                ;  --- LOAD R2 WITH BYTE COUNT
                                ;
                                        .TITLE HDUMP.MAC
                                        .MCALL  .TTYOUT
                                ;
                                ;
000000  111103                  HDUMP:: MOVB    (R1),R3         ;LOAD R3 WITH DATA BYTE
000002  004767  000020                  JSR     PC,HEXOUT       ;OUTPUT BYTE IN HEX
000006                                  .TTYOUT SPACE           ;OUTPUT SPACE
000016  005201                          INC     R1
000020  005302                          DEC     R2
000022  001366                          BNE     HDUMP           ;LAST BYTE ?
000024  000207                          RTS     PC
                                ;
000026  110346                  HEXOUT: MOVB    R3,-(SP)        ;SAVE BYTE
000030  072327  177774                  ASH     #-4,R3          ;SELECT HI 4 BITS
000034  004767  000010                  JSR     PC,SEND         ;SEND IT
000040  112603                          MOVB    (SP)+,R3        ;RETRIEVE BYTE
000042  004767  000002                  JSR     PC,SEND         ;SEND LO 4 BITS
000046  000207                          RTS     PC
                                ;
000050  142703  000360          SEND:   BICB    #360,R3         ;CLEAR HI 4 BITS (OF BYTE)
000054  120327  000012                  CMPB    R3,#10.         ;VALUE LESS THAN 10 ?
000060  100403                          BMI     LT10            ;  -YES,GOTO LT10
000062  062703  000067                  ADD     #<'A-10.>,R3    ;ADD BASE ALPHANUMERIC OFFSET
000066  000402                          BR      OUT
000070  062703  000060          LT10:   ADD     #'0,R3          ;ADD BASE NUMBER OFFSET
000074  110300                  OUT:    MOVB    R3,R0
000076                                  .TTYOUT                 ;OUTPUT CHARACTER
000102  000207                          RTS     PC
                                ;
000104     040                  SPACE:  .ASCII  / /             ;ASCII SPACE
                                ;
        000001                          .END
```

```
HDUMP.MAC      MACRO V04.00  31-MAY-83 16:04:36 PAGE 1-1
SYMBOL TABLE

HDUMP   000000RG       LT10    000070R        OUT     000074R        SEND    000050R        SPACE   000104R
HEXOUT  000026R

. ABS.  000000    000
        000105    001
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  8192 WORDS  ( 32 PAGES)
DYNAMIC MEMORY AVAILABLE FOR  54 PAGES
HDUMP,LP:=HDUMP
```

III.14 CONVRT

```
FORTRAN IV      V02.5-5    Wed 03-Aug-83 00:06:50                    PAGE 001

      C *************************************************
      C
      C  PROGRAM CONVRT.FOR - DATA CONVERSION
      C                6-APR-83
      C                D.VOELZ
      C
      C *************************************************
      C
      C  THIS PROGRAM CONVERTS BINARY FILES OF LIDAR
      C  DATA TO ASCII FILES. THIS IS NECESSARY FOR
      C  THE TRANSFER OF DATA TO THE CYBER.
      C  THE PROGRAM ALSO ALLOWS THE GROUND SPEED (KTS),
      C  ALTITUDE (FT), LATITUDE (DEG.-MIN), AND
      C  LONGITUDE (DEG.-MIN) TO BE ADDED TO THE ASCII
      C  FILE.
      C
      C  THE ASCII FILE FORMAT IS AS FOLLOWS:
      C
      C      WRITE(4,120)BINS,LBI,CSET,CPROF,MN,DAY,YR,HRS,MINS,SECS
      C  120 FORMAT(4I5,6I3)
      C
      C      WRITE(4,125)GSPD,ALT,LAT,LONG
      C  125 FORMAT(I5,F7.3,2F7.1)
      C
      C      WRITE(4,128)(LDATA(I),I=1,BINS)
      C  128 FORMAT(12(I5))
      C
      C  *** NOTE *** IN THE PROGRAM ALL THE FORMAT STATEMENTS ABOVE
      C               BEGIN WITH A '1X'. THIS IS SIMPLY THE CONTROL
      C               CHARACTER.
      C
             PROGRAM CONVRT
             INTEGER DSET,NPROF,GSPD(99),MN,DAY,YR,LDATA(2100)
             INTEGER HDRB,BINS,INTSIZ,LBI,RECSIZ,CSET,CPROF
             INTEGER HRS,MINS,SECS
             REAL ALT(99),LAT(99),LONG(99)
             LOGICAL*1 DEVF(4),DEVT(4),EXT(3),NAMEF(15),NAMET(15)
             LOGICAL*1 ITIME(8)
             INTEGER*4 JTIM
      C ==============================
      C  INPUTS
      C ==============================
      C
      C  INITIAL VALUES
      C
             HDRB=9
             DATA NAMEF/0,0,0,0,'S','E','T',0,0,0,'.','D','A','T',0/
             DATA NAMET/0,0,0,0,'S','E','T',0,0,0,'.','A','S','C',0/
      C
      C  GET INITIAL RESPONSES (DEVICE,SET #,# OF PROFILES)
      C
             TYPE 10
             READ(5,15) (DEVF(I),I=1,4)
             TYPE 20
```

```
      READ(5,15) (DEVT(I),I=1,4)
   27 TYPE 30
      READ(5,*) DSET
      TYPE 40
      READ(5,*) NPROF
C
   10 FORMAT(' ',T32,'DATA CONVERSION',///T5,'DEVICE:',/T5
     >,' From ? ',$)
   15 FORMAT(4A1)
   20 FORMAT(' ',T5,' To ? ',$)
   30 FORMAT('0',/T5,'SET # ? ',$)
   40 FORMAT(' ',T5,'TOTAL # OF PROFILES IN SET ? ',$)
C
C  INPUT GROUND SPEED,ALTITUDE,LATITUDE,LONGITUDE
C
        DO 90 K=1,NPROF
        TYPE 50,DSET,K
        TYPE 52
        READ(5,*) GSPD(K)
        TYPE 56
        READ(5,*) ALT(K)
        TYPE 60
        READ(5,*) LAT(K)
        TYPE 64
        READ(5,*) LONG(K)
   90   CONTINUE
C
   50 FORMAT('0',/T5,'SET #      ',I3,/T5,'PROFILE # ',I3)
   52 FORMAT(' ',T5,'Ground Speed (KTS) ?      ',$)
   56 FORMAT(' ',T5,'Altitude (FT) ?           ',$)
   60 FORMAT(' ',T5,'Latitude (DEG.-MIN.) ?   ',$)
   64 FORMAT(' ',T5,'Longitude (DEG.-MIN.) ? ',$)
C ==============================
C  CONVERT FILES
C ==============================
C
C  SET UP FILE NAMES (SETXXX.DAT --> SETXXX.ASC)
C
        DO 70 I=1,4
        NAMEF(I)=DEVF(I)
        NAMET(I)=DEVT(I)
   70   CONTINUE
C
       ENCODE(3,80,EXT)DSET
   80 FORMAT(I3)
        DO 85 I=1,3
        NAMEF(7+I)='0'
        NAMET(7+I)='0'
        IF(EXT(I).EQ.' ') GOTO 85
        NAMEF(7+I)=EXT(I)
        NAMET(7+I)=EXT(I)
   85   CONTINUE
C
C  CALCULATE RECORDSIZE FOR OLD FILE AND INITIAL BLOCK SIZE
```

```
C  FOR NEW FILE
C
      OPEN(UNIT=3,TYPE='OLD',RECORDSIZE='2',NAME=NAMEF,ACCESS=
     >'DIRECT',FORM='UNFORMATTED')
      READ(3'1)BINS
      CLOSE(UNIT=3)
      RECSIZ=(BINS+HDRB+1)/2
      INTSIZ=IFIX((FLOAT(NPROF)*(BINS+15)/256.+1.1)*6.)
C
C  OPEN OLD & NEW FILES
C
      OPEN(UNIT=3,TYPE='OLD',RECORDSIZE=RECSIZ,NAME=NAMEF,ACCESS=
     >'DIRECT',FORM='UNFORMATTED')
      OPEN(UNIT=4,TYPE='NEW',INITIALSIZE=INTSIZ,NAME=NAMET)
C -----------------------------
C  CONVERT DATA BY PROFILES (K=PROFILE #)
C -----------------------------
      DO 100 K=1,NPROF
      READ(3'K)BINS,LBI,CSET,CPROF,MN,DAY,YR,JTIM,
     >(LDATA(I),I=1,BINS)
C
C  CONVERT ALTITUDE FROM FEET TO KILOMETERS
C
      ALT(K)=ALT(K)*.0003048
C
C  CONVERT TIME
C
      CALL TIMASC(JTIM,ITIME)
      ITIME(3)=ITIME(4)
      ITIME(4)=ITIME(5)
      ITIME(5)=ITIME(7)
      ITIME(6)=ITIME(8)
      DECODE(6,115,ITIME)HRS,MINS,SECS
  115 FORMAT(3I2)
C
C  WRITE ASCII FILE
C
      WRITE(4,120)BINS,LBI,CSET,CPROF,MN,DAY,YR,HRS,MINS,SECS
  120 FORMAT(1X,4I5,6I3)
      WRITE(4,125)GSPD(K),ALT(K),LAT(K),LONG(K)
  125 FORMAT(1X,I5,F7.3,2F7.1)
      WRITE(4,128)(LDATA(I),I=1,BINS)
  128 FORMAT(1X,12(I5))
C
  100 CONTINUE
C -----------------------------
C  CLOSE OUT FILES
C -----------------------------
      CLOSE(UNIT=3)
      CLOSE(UNIT=4)
      TYPE 130,CSET
  130 FORMAT('0',T5,'SET # ',I3,' CONVERTED')
C
C  RETURN FOR NEXT SET
C
      GOTO 27
C
      END
```

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```
FORTRAN IV      Storage Map for Program Unit CONVRT

Local Variables, .PSECT $DATA, Size = 013112 ( 2853. words)

Name    Type  Offset        Name    Type  Offset        Name    Type  Offset
BINS    I*2   013052        CPROF   I*2   013064        CSET    I*2   013062
DAY     I*2   013044        DSET    I*2   013036        HDRB    I*2   013050
HRS     I*2   013066        I       I*2   013100        INTSIZ  I*2   013054
JTIM    I*4   013074        K       I*2   013102        LBI     I*2   013056
MINS    I*2   013070        MN      I*2   013042        NPROF   I*2   013040
RECSIZ  I*2   013060        SECS    I*2   013072        YR      I*2   013046

Local and COMMON Arrays:

Name     Type   Section  Offset  ------Size-----  Dimensions
ALT      R*4    $DATA    010456  000614 (  198.)  (99)
DEVF     L*1    $DATA    012722  000004 (    2.)  (4)
DEVT     L*1    $DATA    012726  000004 (    2.)  (4)
EXT      L*1    $DATA    012732  000003 (    2.)  (3)
GSPD     I*2    $DATA    000000  000306 (   99.)  (99)
ITIME    L*1    $DATA    012773  000010 (    4.)  (8)
LAT      R*4    $DATA    011272  000614 (  198.)  (99)
LDATA    I*2    $DATA    000306  010150 ( 2100.)  (2100)
LONG     R*4    $DATA    012106  000614 (  198.)  (99)
NAMEF    L*1    $DATA    012735  000017 (    8.)  (15)
NAMET    L*1    $DATA    012754  000017 (    8.)  (15)

Subroutines, Functions, Statement and Processor-Defined Functions:

Name    Type   Name    Type   Name    Type   Name    Type   Name    Type
FLOAT   R*4    IFIX    I*2    TIMASC  R*4
```

APPENDIX IV PREPROCESSING SYSTEM OPERATION PROCEDURE

IV.1 Data Collection

The following is the procedure for assembling and operating the lidar preprocessing system for sodium profile data collection.

1. Connect the components of the receiving system as shown in Figure IV.1. Note the following items:

   (a) Three cards are required in the Apple peripheral slots: the CCS serial card in slot 2, the DMA card in slot 4, and the disk controller card in slot 6.

   (b) Be sure to use the cable designated "Apple-LSI-11" between the Apple CCS card and the LSI-11 DLV11-J card channel 0.

   (c) Use the shielded ribbon cable between the Apple and the SIIPP unit.

2. Connect the monitor output of the Discriminator High Voltage Supply to a digital voltmeter.

3. Check the settings of the following components:

   Laser Control Unit - Trigger mode external

   Discriminator - single mode, V = 1, ΔV = don't care, threshold multiplier = X10

   PMT Timing Controller - blanking on, μP gate don't care, triggering external, internal rate don't care.

4. Check the setting of the Discriminator High Voltage Supply by first disconnecting the HV cable on the HV Output and then turning on the supply. The voltage should be adjusted until the monitor voltmeter reads about 2 volts (2000 volts HVS output). Shut off the supply and reconnect the HV cable.

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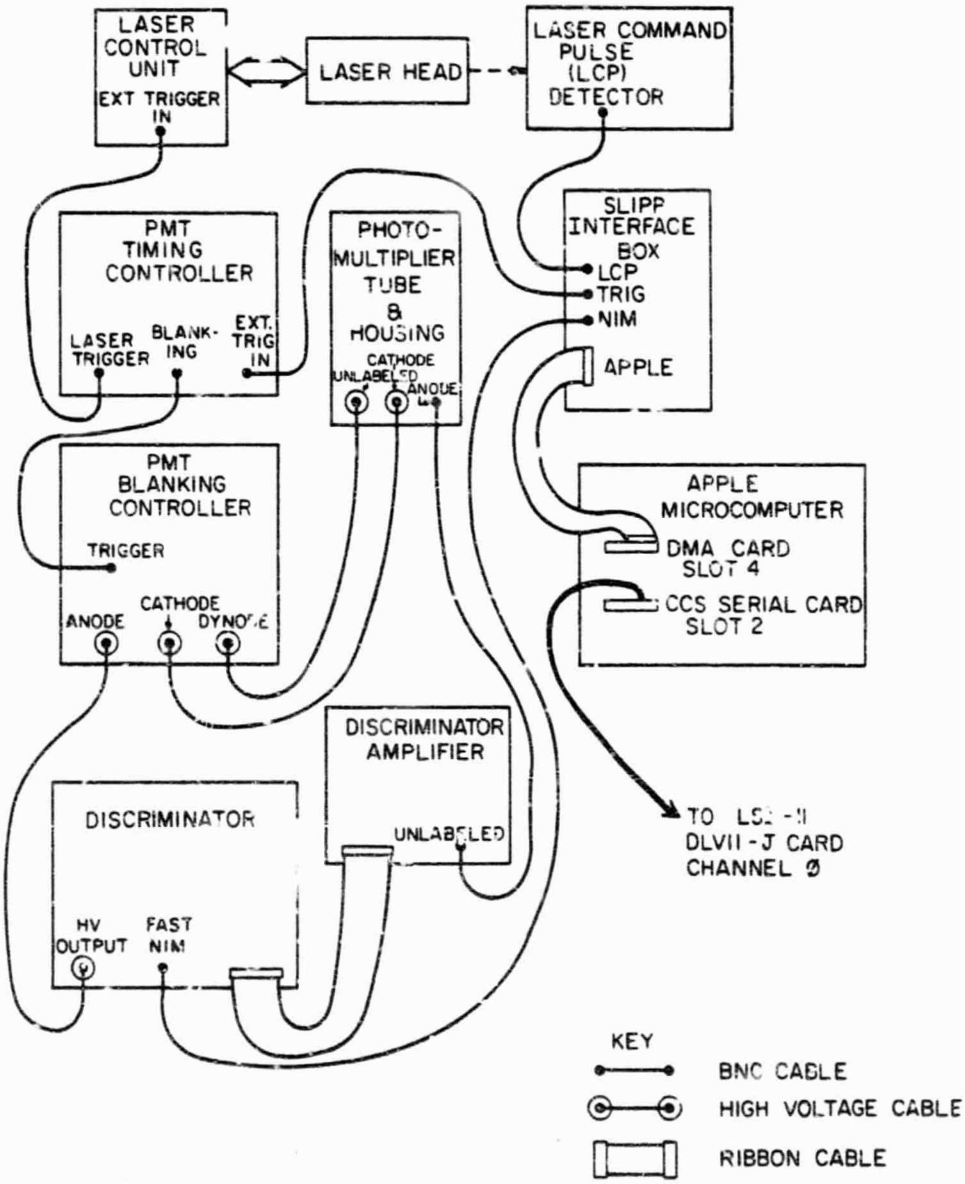

Figure IV.1 Lidar receiver connection map.

5. Power up all of the components except the Apple and LSI-11 computers. The order in which the components are switched on is not critical.
6. Load one of the Apple lidar software floppy disks into the Apple drive and switch on the Apple. Wait for the computer to boot up. Run the collection program SLPAPP.OBJ (BRUN SLPAPP.OBJ).
7. Load one of the LSI-11 lidar software floppy disks into the LSI-11 system drive and switch on the LSI-11. Wait for the computer to boot up. Load a LSI-11 data floppy disk into the storage drive. (Normally the DX1: or DY1: drive is used as the system drive and DX0: or DY0: is used as the storage drive. For more details see Section 5.4 on Data Collection Software Options.) Run the collection program FZZ.SAV (RUN FZZ).
8. The preprocessing system should now be operational. The laser-telescope alignment and data collection routines can be run by following the prompts on the Apple and LSI-11 monitors.

Notes:

(a) Remember to power up the PMT cooling housing unit a few hours before the data collection to allow the PMT to cool sufficiently.

(b) In order for the preprocessing system to trigger the laser the trigger mode selector switch must be set to "external." However, the trigger mode switch can be set to "internal" for laser tuning or alignment of optics.

(c) Two pulse delay circuits are provided on the laser control unit. The circuits provide a delay between an input trigger pulse and an output pulse with the duration of the delay set by an adjustment knob on the control unit. Normally, delay circuit #2 is incorporated between the input laser trigger pulse and the final

trigger pulse sent to the laser head. Thus, there is a delay between the preprocessing system laser trigger pulse and the actual laser firing. If the delay is too long, it is possible for the Apple in the preprocessing system to send the laser trigger pulse and then test to see if the collection is complete before the laser ever fires. This results in a laser trigger error message. If the laser is firing at approximately the same time as the Apple is testing for collection completion, some peculiar behaviors can result (such as the Apple "hanging"). These problems can be alleviated by reducing the delay with the adjustment knob (normally, #2 ADJ).

IV.2 Testing

The following is a procedure for assembling and testing the preprocessing system without the rest of the lidar system components.

1. Connect the preprocessing system components (Apple, LSI-11, and SLIPP unit) as shown in Figure IV.1. However, do not connect the three SLIPP unit lines LCP, TRIG, and NIM to the receiving components. (Also, note the appropriate items in Section IV.1.)
2. Connect the TRIG BNC output on the SLIPP unit to the LCP BNC input. This loop simulates the laser in the system.
3. Connect a source of simulated photon pulses to the NIM BNC on the SLIPP unit. The pulses can be supplied by a couple of methods:
   (a) Use the PMT and the Discriminator-Amplifier as shown in Figure IV.1 and simply leak a small amount of light into the PMT.
   (b) Use a pulse generator with output pulses of about -1 V and 1-20 MHz.

4. Follow the steps outlined in Section IV.1 (steps 6-8) for loading the Apple and LSI-11 disks and running the collection programs. However, a slightly altered version of the Apple collection program must be used because of some timing difficulties due to the TRIG-LCP loop. This program is labeled SLPTST.OBJ and should also be provided on the Apple lidar software disks.

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